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Vol. V

TRANSCRIPT OF RECORD

(Pages 1141 to 1592)

Supreme Court of the United States

OCTOBER TERM, [illegible] 1946

No. [illegible] 24

HALLIBURTON OIL WELL CEMENTING COMPANY,
PETITIONER,

vs.

CRANFORD P. WALKER AND CRANFORD P. WALKER, D. A. WALKER, ET AL., DOING BUSINESS AS DEPTHOGRAPH COMPANY, COPARTNERSHIP

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 2, 1946.

CERTIORARI GRANTED OCTOBER 15, 1946.

Office - Supreme Court, U. S.
FILED
AUG 2 1945
CHARLES ELMORE CROPLEY
CLERK

TRANSCRIPT OF RECORD
IN SIX VOLUMES

IN THE

Supreme Court of the United States

October Term, 1945

No. 290

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Petitioner,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Respondents.

VOLUME V

Book of Exhibits
(Defendant's Exhibits—Part II)
Pages 1141 to 1591

UPON PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT

Rotary Colorprint, 661 Howard Street, San Francisco

No. 10513

United States
Circuit Court of Appeals
For the Ninth Circuit.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellant,

vs.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellees.

CRANFORD P. WALKER and CRANFORD P. WALKER, D. A. WALKER, ROBERT P. MILLER and MILO C. KETCHUM, doing business as Depthograph Company, a copartnership,

Appellants,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY, a Delaware corporation,

Appellee.

Transcript of Record
In Five Volumes
VOLUME V
Book of Exhibits
(Defendant's Exhibits—Part II)
Pages 1141 to 1591

Upon Appeals from the District Court of the United States for the Southern District of California, Central Division

Rotary Colorprint, 590 Folsom St., San Francisco

DEFENDANT'S EXHIBIT Q

309

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents, in the matter of the

Abandoned Application of
Cranford P. Walker,

Serial Number 171,170
for
Improvement in Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this fourth day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

[Seal] CONWAY P. COE
Commissioner of Patents.

Attest:
D. E. WILSON,
Chief of Division.

NUMBER (Series of 1935)

171170

DIV. 44 3K

PATENT NO.

DATED MAY - 2 1939

(EX'R'S BOOK) 54, 493/37

ABANDONED

Name CRAWFORD P. WALKER

This application referred to in Patent No. 2161733 Do not destroy. (See order No. 3166, 400 O.G. 1)

DO NOT DETACH

of SAN MARINO

State of CALIFORNIA

Invention METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND PRODUCTION CAPACITY OF OIL WELLS

Defendant's Exhibit Q—(Continued)

Mail Division Oct 25 1937 U. S. Patent Office.

Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
MAdison 1137

October 22, 1937.

Oct-26-37 O 76887D Check—30.0
Oct-26-37 O 76387D Check—14.0
1/86

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Attached is application for Letters Patent of the United States executed October 20, 1937 by Cranford P. Walker for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells; also attached is my check No. 271 in the amount of $44.00 to cover the Government filing fee. (34 claims).

Respectfully,
HAROLD W. MATTINGLY.

MM
Encls.

Defendant's Exhibit Q—(Continued)
U. S. Patent Office Nov. 3-1937. Division 36.
Mail Division Oct. 25-1937. U. S. Patent Office.

PETITION

To the Commissioner of Patents:

Your petitioner, Cranford P. Walker, a citiz. of the United States, residing at San Marino, in the County of Los Angeles, and the State of California, whose post office address is 2824 Carlaris Road, San Marino, California, prays that Letters Patent may be granted to him for the Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells set forth in the annexed specification, and he hereby appoints

Harold W. Mattingly
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
(Registry No. 12,385)

his attorney with full power to substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

(Sign here first name in full)

CRANFORD P. WALKER.

SPECIFICATION

To All Whom It May Concern:

Be It Known, That I, Cranford P. Walker, a citi-

Defendant's Exhibit Q—(Continued)

zen of the United States, residing at San Marino, in the County of Los Angeles, and State of California, have invented certain new and useful improvements in Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells of which the following is a specification:

My invention relates to methods of determining the fluid density, fluid pressure and potential production capacity of oil wells and has particular reference to methods of determining the most desirable character of pumping equipment and manner of operating the same to permit an efficient production of oil from a given well.

It is the common practice in oil well production activity to permit an oil well to produce as a flowing well, that is to permit the oil to flow out at the ground surface due to the pressure in the oil formations, until the production rate reaches a considerably low value or ceases, after which gas lifting is usually attempted and continued until the production rate with gas lifting reaches a relatively low value or the production entirely ceases. At this time, and in some instances prior to any attempt to gas lift the oil, mechanical pumping devices are usually installed to lift the oil by mechanical means to the surface, these pumps usually comprising a pump barrel located at a considerable depth in the well, usually 50 to 150 feet below the surface of the liquid in the well while it is producing, plungers or other reciprocating devices being employed in the

Defendant's Exhibit Q—(Continued)

barrel and operated from the ground surface by means of sucker rods.

Usually the selection of the size and character of the pumping equipment is determined by the production of the well during its flowing or gas lifting life by estimating from this production the type or character of pump which appears to be most suitable. In many fields, however, the type, size and character of the pump installed is usually one determined as "standard for that particular type of well in the particular field. In other words, it is one having the same dimensions as pumps in other wells producing from the same horizon. Frequently, such well receives no further attention until the field as a whole has declined to a point where it becomes necessary to increase the production from the wells, as for example, by the encroachment of water necessitating the lifting of greater quantities of fluid in order to obtain the desired amount of oil. When this condition occurs, it is customary to increase the capacity of the pumping equipment.

Also, the production from a given well may be believed to be less than the character of the well and the character of the pumping equipment employed should indicate, as for example, the pump may be operating at a relatively low volumetric efficiency.

In order to determine whether or not any change in the size, character, operating characteristics or location of the pumping apparatus should be made,

Defendant's Exhibit Q—(Continued)

it is desirable that the location of the liquid surface, the character of the liquid in the well, its density and the fluid pressure at any given point below the surface of the liquid and the maximum potential production capacity of the well should be determined.

For example, if the pumps in a particular field are operating at good volumetric efficiency, much can be determined from the quantity of oil produced and the volumetric displacement per stroke of the pump, and if the pumps are operating at their maximum capacity, the fact that the fluid level is at a considerable distance above the pump inlet may indicate that the operator is justified in making a change in the size or character of the pumping equipment. Again, if the volumetric efficiency of the pump is found to be low, as for example, when the pump appears to be taking in a comparatively large quantity of gas upon each stroke of the pump, the operator should know whether or not the inlet of the pump is located at point too near the liquid surface so that he may determine how far below the liquid surface he should lower the pump in order to allow it to receive liquid for the full stroke.

Frequently in wells where the quantity of gas produced by the well is relatively small, an increased production of the pump may be obtained by raising the pump to a point nearer the liquid surface so that a better separation of the gas takes place prior to the entry of the liquid into the pump, while if the well is ~~taking~~ making a large quantity of gas,

Defendant's Exhibit Q—(Continued)

it may be better to lower the pump to a point below where the gas is separated from the liquid so that upon each stroke of the pump, dense fluid will be picked up. However, in many instances, it is dangerous to lower the pump too close to the bottom as sand is likely to be pumped into and foul the pump.

In wells where the fluid level is so low that the pump is not completely submerged and hence does not receive a full cylinder or barrel of fluid upon each stroke, a pounding at the pump is created which may be heard or determined at the ground surface. This same character of pounding, however, may be produced by the pump even though the liquid surface is at a considerable distance above the pump inlet, occasioned by the inflow into the pump of large quantities of free gas. Hence, simple tests to determine the fluid level relative to the pump inlet will not produce the desired information to the operator as to the desirable character or location of the pumping mechanism.

If, however, the fluid pressure at different levels below the surface of the fluid is determined, this information may be employed to determine the most desirable location of the pump and whether or not a change should be made in the size, operating characteristics or character of the pumping equipment employed in a given well to produce an increased or maximum production from the well.

The determination of the fluid pressure at different points below the surface of the well may be de-

Defendant's Exhibit Q—(Continued)

termined by instruments known as pressure record-
either
ers, which must be ∧ attached to ~~either~~ the pump or lowered into the well to the desired level, or must be lowered into the well on wires, cables or other supporting devices and left at the desired levels for a predetermined length of time necessary to permit the recorders to make a chart or record of the pressures encountered. All of these methods however require the stopping of the pumps and the stopping of production while the test is being made and further require the removal of the pumps and sucker rods and sometimes the tubing and other apparatus from the well in order to insert the pressure recorders or pressure measuring devices, which entails considerable labor and time and holds up the production of the well for a considerable period of time.

It is therefore an object of my invention to provide methods for determining the fluid pressure at
standing column of
any given point below the surface of the ∧ liquid in the well, determining the density of the liquid in
such column
~~the well~~ ∧ and the production index of the well without interrupting or interfering with the produc-
by the usual pumping apparatus employed therein
tion of the well ∧.

Another object of my invention is to provide a ready means for determining the fluid pressure at
of the standing column of
liquid in the well
any level below the ~~fluid~~ surface ∧ and for determining the density of the liquid in any particular well

Defendant's Exhibit Q—(Continued)

without necessitating the removal or replacement of any of the usual pumping apparatus, flow tubes, sucker rods or other mechanism found in a ~~produc-~~ being produced by a mechanical pump ~~ing~~ well ∧.

Another object of my invention is to provide information to aid in the determining of the proper location of a pump in an oil well to achieve the maximum volumetric efficiency of the pump in handling the particular character of fluid found in the particular well.

Another object of my invention is to provide a ready method for determining the potention production capacity of an oil well with a minimum of expense, delay or interruption of the production activities of the well.

Another object of my invention is to provide a ready method of determining the static fluid of pressure in oil wells without requiring the removal or replacement of any of the pumping apparatus.

Another object of my invention is to provide a ready method of determining the pressure of the fluid at any point in a well, including the entrance to the pump, by displacing the liquid by means of gas pressure down to the point where it is desired to know the fluid pressure. The normal fluid pressure existing at this point is the sum of the gas pressure at the well casing head and the pressure exerted on the liquid surface due to the weight of the gas above it.

Another object of my invention is to provide a

Defendant's Exhibit Q—(Continued)

ready means for determining the pressure of the fluid in a well at any level therein by measuring the difference in the height of the surface of the fluid under two conditions of pressure upon the surface of the fluid.

Another object of my invention is to provide a method of determining the density of the fluid in a well by measuring the amount of recession of the level of the liquid surface under two conditions of pressure upon the liquid surface and computing from the facts thus obtained the density of the fluid in the well. Fluid densities in producing wells range all the way from less than .04# per square inch to over .4# per square inch per 100 feet of fluid in the well. Therefore, a simple fluid level determination without a density or pressure determination gives very little information.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by measuring the pressure at the pump inlet under two conditions of operation of the pump and computing therefrom the maximum potentional production obtainable from the well.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by measuring the static pressure at the pump inlet and measuring the pressure at the pump inlet for at least one rate of production of the pump and computing therefrom the maximum possible production obtainable from the well.

Defendant's Exhibit Q—(Continued)

Other objects of my invention will be apparent from a study of the following specification read in connection with the accompanying drawing, wherein

Fig. 1 is a diagrammatic, cross-sectional view of a typical oil well, illustrating the level of the liquid surface as being located a considerable distance above the inlet of the pumping apparatus employed.

Fig. 2 is a view similar to Fig. 1 but illustrating the effect on the liquid surface of gas pressure allowed to build up in the casing.

Fig. 3 is a view similar to Figs. 1 and 2 illustrating the effect on the level of the liquid surface under other conditions of pressure existing within the casing of the well and illustrating the manner in which the location of the liquid surface at the pump inlet may be detected.

Fig. 4 is a diagrammatic view illustrating a chart or graph which may be employed in the practice of my method for the computation of fluid density and pressures at different locations or levels within the well.

Fig. 5 is a diagrammatic view illustrating a chart or graph which may be employed to compute the maximum potential capacity of a well from a comparison of the pressure at the pump while it is idle with the pressure at the pump while it is operating normally.

Defendant's Exhibit Q—(Continued)

Fig. 6 is a view similar to Fig. 5 illustrating the manner in which a more accurate computation of the potential capacity of a well may be obtained by comparing the pressure at the pump under two production rates of the pumping apparatus.

Referring to the drawings, I have illustrated in Fig. 1 a typical oil well which includes a casing 1 extending down through the well bore from the ground surface 2 into the oil producing sands, the oil flowing from the sands or oil formation into the casing and rising in the casing to some level indicated at 3. Pumping apparatus employed to remove the oil from the well usually includes a suitable pump 4 located upon tubing string 5, constituting the flow tubing through which the oil is raised to the ground surface, the pump 4 including usually some reciprocating mechanism operated by reciprocal movements of a string of sucker rods 6 extending down through the tubing 5 and connected to reciprocating power apparatus at the ground surface, as indicated at 7. The flow tubing 5 is provided with an outlet 8 communicating with a suitable oil line through which the oil pumped from the well is conveyed to any desired location.

The casing 1 is closed at its upper end as indicated at 9, an outlet being provided communicating with the casing 1 to permit gas escaping from the oil to pass into a suitable gas line 11, a control valve 12 being usually provided to control the flow of gas into the gas line.

Defendant's Exhibit Q—(Continued)

By properly selecting the size, the stroke and the speed of the pump 4, the pump may be made to remove the oil from the well at approximately the same rate at which the oil flows into the well from the surrounding formation, and if so selected, the well will be operated at its maximum capacity. However, oil coming from the formation contains relatively large quantities of gas which, due to the pressure of the oil, cannot readily escape but which when the oil enters the pump tends to expand in the pump, reducing the volumetric efficiency of the pump. If now the pump is so located relative to the liquid surface that the greater portion of the gas within the well has been permitted to escape prior to the entry of the oil into the pump, it follows that upon each stroke of the pump, the pump will be operated upon relatively dense fluid and will hence operate at relatively high volumetric efficiency.

I have discovered ready means for determining not only the pressure existing at the pump without requiring the removal of the pump or any of its apparatus but also I have discovered a ready method for determining the density of the fluid at the pump entrance, the information so obtained being used in the location of the pump at the most desirable level to obtain the maximum volumetric efficiency of the pump.

To obtain the information required, I measure or determine the stable location of the liquid surface

Defendant's Exhibit Q—(Continued)

of the "standing column" of liquid within the well ∧ when the pump is operating at its normal production capacity and with the pressure of gas within the casing at the usual or normal value maintained during the usual or normal pumping operations at the well. (∧ D^2) This location of the fluid level may be readily accomplished by employing the methods and apparatus disclosed in United States Letters Patent No. 2,047,974 issued to Harold T. Wyatt and Paul E. Lehr, July 21, 1936, and in my copending applications Serial No. 162,699 filed September 7, 1937, and Serial No. 164,534 filed September 18, 1937. While the methods and apparatus are completely disclosed in the said patent and applications, the method may be stated briefly as including

annular space between the tubing 5 and the

the introduction into the ∧ well casing of a sudden change in pressure in the well casing and measuring the length of time elapsing between the production of this pressure impulse and the return to the ground surface of the echo thereof from the surface of the fluid. By noting the distance from the ground surface of the fluid level under these conditions and by noting the pressure of gas at the casing head, as by means of a pressure gauge 13,

∧ the pressure on the liquid surface may be computed as follows: To the casing head pressure is added the effect of pressure on the liquid surface exerted by the weight of the column of gas between the liquid surface and the casing head. A

Defendant's Exhibit Q—(Continued)

gravity test may be made of the gas at the casing head which will determine the pressure exerted by each foot or hundred feet of height of the gas column. This information may be computed by the following formula which is by Dice:

$$\text{Log}_{10}\text{Pb} = \frac{\text{SD}}{122.82\text{T}} + \text{Log}_{10}\text{Pt}$$

Where

Pb = Lbs/sq. in. absolute at bottom of gas column.

Pt = Lbs/sq. in. absolute at top of gas column.

S = Specific gravity of the gas (air is considered 1).

D = Depth from casing head to liquid surface.

T = Mean temp. of the gas column in degrees F absolute.

This information may then be plotted upon a graph or chart as illustrated in Fig. 4 in which the conditions existing in the particular well under measurement are assumed to be such that with a pressure of 36 pounds per square inch at the casing head, the liquid surface is found to lie at 3100′ below the casing head. The specific gravity of the gas in this instance may be found to be such that the effect will be to produce 4 pounds per square inch pressure on the liquid surface. Thus, the addition of 36 pounds and 4 pounds produces a total pressure on the liquid surface of 40 pounds per square inch. By arranging the chart shown in Fig. 4 with the ordinates representing the fluid level measured from the ground surface and the abscissae representing pres-

Defendant's Exhibit Q—(Continued)

sure on the liquid surface in pounds per square inch, the point L1 determined from the preceding formula may be plotted on the chart shown in Fig. 4.

Now, the valve 12 is closed or a suitable pressure regulator is placed in the gas line 11 and the pressure within the casing is allowed to build up to any predetermined value. As the pressure builds up, the oil level 3 tends to recede. By continuing the operations of the pump during the building up of this pressure, preferably for a period substantially equal to the time required for the pump to remove the column of fluid between the original fluid level and a new fluid level to which the pressure depresses the liquid surface, represented at 3a (Fig. 2) multiplied by 3, it will be found that a stable condition will be achieved at which the fluid level will become constant and the production by the pump will be approximately the same as before the pressure was allowed to build up in the casing. When this stable condition is reached, a second measurement of the fluid level is obtained by the level measuring methods and apparatus hereinbefore described.

Having determined the new location of the liquid surface, the pressure exerted thereon may now be calculated as follows: Assuming that the casing head pressure in this instance was adjusted to 170 pounds, to this should be added the pressure due to the weight of the column of gas above the new fluid level. The determination of the effect of the

Defendant's Exhibit Q—(Continued)

weight of the column of gas upon the fluid level may be obtained either by calculation or may be plotted out and obtained from suitable charts prepared for this purpose. In this instance, it may be assumed that the pressure due to the gas column is 30 pounds per square inch, making a total of 200 pounds per square inch on the fluid. Now, assuming that the level to which the ∧ ~~fluid~~ has receded is 3966′ from the top of the well, the new point L2 shown in Fig. on the chart ∧ 4 representing the new level and the pressure on the liquid surface may be placed upon the chart. From an exhaustive series of actual tests, it has been discovered that the relation between the pressure on the liquid surface and the distance through which the fluid will recede in any given well having a uniform cross-sectional area is Shown in Fig. constant, so that a line drawn on the chart ∧ 4 intersecting the points L1 and L2 will truly represent the fluid level at any of the pressure ∧ s which may be placed upon the fluid column. Thus, by merely extending the line C downwardly on the chart until it crosses the ordinate representing the location of the pump inlet indicated on the chart as A, a direct reading of the fluid pressure required to cause the surface of the column to recede to the pump inlet is obtained. On the chart this is represented as 336 pounds per square inch, which is the

Defendant's Exhibit Q—(Continued)

pressure at the pump for the normal rate of production, assuming that the rate of production was normal during the tests.

The actual pressure in the column of ∧ ~~oil~~ liquid at the pump inlet may, however, be calculated from the information received by the two fluid level tests described above. That is, by subtracting the original fluid level from the new fluid level, the total difference in the level will be found in this instance 866'. Then, by subtracting the original pressure on the liquid surface from the new pressure on the liquid surface, a difference of 160 pounds per square inch is found to have been necessary to cause the ∧ ~~fluid~~ liquid column to recede 866'. By dividing the difference in fluid pressure by the difference in surface level, the density of the ∧ ~~oil~~ liquid mixture of oil and gas in the well ($\wedge D^4$) may be found. In this instance, the column receded a distance between 3100' and 3966' or a total distance of 866', while the pressure difference is 160 pounds. The density of the ∧ ~~oil~~ liquid is such therefore as to exert 0.185 pounds per square inch per foot of height of the column.

Hence, knowing the pressure on the fluid surface at any level thereof and knowing the distance below this surface at which the pump inlet is located, a direct calculation of the fluid pressure at the pump inlet may be obtained by the following formulae:

The pressure at any point below the normal fluid

Defendant's Exhibit Q—(Continued)

level in a well at which the level can be maintained by means of gas pressure in the casing is PL1 = Pc1 + Pg1 and PL2 = Pc2 + Pg2. The density of the fluid for the rate of production during the tests is

$$D = \frac{PL2 - PL1}{L2 - L1}$$ = density of the fluid in lbs. per sq. in. per ft. of fluid.

The pressure at the pump is Pa = D(La—L2) + PL2 where

Pc1=gage casing pressure to maintain fluid at level L1.

Pc2=gage casing pressure to maintain fluid at level L2.

Pg1=pressure exerted upon fluid surface by weight of gas above it at level L1.

Pg2=ditto for level L2.

PL1=pressure on the fluid surface at level L1.

PL2=pressure on the fluid surface at level L2.

L1 =fluid level corresponding to Pc1.

L2 =fluid level corresponding to Pc2.

La =pump location in feet from ground surface.

Pa =pressure at the pump.

In the example shown in Fig. 4, assuming the inlet to the pump is located at the 4700′ level, the pressure of the oil at this point would be equal the sum of the gas pressure at the casing head for level L2, the pressure exerted by the column of gas above liquid the ∧ ~~fluid~~ surface corresponding to this level and the pressure exerted by the column of oil above the

Defendant's Exhibit Q—(Continued)

pump inlet. In this instance, the pressure at the casing head is assumed to be 170 pounds per square inch, the effect of the column of gas at this pressure with the fluid level at 3966′ from the surface being 30 pounds per square inch and the effect of the column of liquid above the pump inlet being 734′ at .185 pounds per square inch per foot, or 135.5 pounds per square inch exerted by the column of liquid, the result being 335.5 pounds per square inch pressure at the pump entrance. This result is clearly illustrated in Fig. 4 by the point A, the point A being located at the 335.5 pound mark on the abscissae of the chart. If desired, an estimation of the bottom hole pressure may also be made by continuing the line C downwardly on the chart to intersect the ordinate representing the bottom of the well, such point being indicated at B, or the pressure at any other level in the well below the surface of the ~~fluid~~ liquid for the rate of production at which the tests were made may be located along the line C. ($\wedge D^5$)

Knowing the density of the oil and the pressure exerted at the pump inlet, the operator of any particular well may determine whether or not it is practicable to increase the amount of fluid being produced. If the volumetric efficiency of the pump is low and the tests indicate considerable pressure at the pump, he may raise the pump to a level indicated upon the line C at which better separation of gas will usually occur prior to entry of fluid into the pump.

Defendant's Exhibit Q—(Continued)

The utilization of the information obtained by the foregoing method will also accurately produce the information of the maximum potential production of the well as by comparing the pressure of the fluid at the pump under two or more different operating conditions of the pump. For example, the static fluid pressure at the pump when the pump is not operating may be measured and compared with the fluid pressure at the pump when the pump is operating at its normal rate of production or at any other rate of production; a comparison of the two values so obtained will produce a constant indicating the ratio between the potential production and pressure at the pump inlet, so that by employing this constant at a theoretical zero pump inlet pressure (which would represent the fluid being removed from the well at the rate it flows into the well from the formation) the maximum potential capacity of the well may be found.

Employing the method of determining fluid pressure at the pump hereinbefore described, the static liquid pressure may be readily obtained without necessitating the use of pressure recorders or other devices requiring the removal of or alteration of any of the pumping mechanism and the measurement may be made in wells which have been shut down as readily as in wells which are actively producing.

To obtain the fluid pressure at any point at or below the liquid surface when the well is not producing fluid, the casing should be closed in and the gas escaping from the liquid should be allowed to build

Defendant's Exhibit Q—(Continued)

up pressure in the casing until a suitable condition is reached, that is, a point is reached at which no more gas is made by the well (no more gas escapes from the liquid). When this point is reached, the remaining fluid in the well may be considered as dense fluid.

Now, by determining the height of the liquid surface under these conditions by my method, the pressure on the liquid surface may be readily determined and by adding thereto the effect of the weight of the column of fluid above any given level, the fluid pressure at that level may be found. This information alone is extremely useful to the operators of producing wells.

The information thus obtained may be plotted on a graph or chart such as that shown in Fig. 5, wherein the ordinates represent fluid pressure at the pump inlet in pounds per square inch and the abscissae represent rate of production of oil from the particular well under consideration, and the static pressure may be plotted at zero production, as indicated by the point D in Fig. 5.

The casing pressure may now be reduced and the pump started and allowed to assume a predetermined rate of production, preferably its normal rate. Assuming this rate is 200 barrels of oil per day, a new determination of the fluid pressure at the pump is made at this rate of production. That is, the pump is started and allowed to operate until the fluid level in the well reaches a stable condition. The location of the fluid level, the pressure in pounds per

Defendant's Exhibit Q—(Continued)

square inch at the pump inlet under these conditions is determined by the method hereinbefore described and the fluid pressure at the pump is plotted against the production rate on the chart shown in Fig. 5. Assuming that this new pressure at 200 barrels per day is found to be at the point indicated in Fig. 5 at E, a straight line drawn between the points D and E will intersect the zero pressure ordinate at a point representing the maximum potential capacity of the well. In the diagram shown in Fig. 5, this maximum potential production capacity is found to be 300 barrels per day. In other words, if a pump of sufficient capacity is installed in this well and operated in such manner as to remove 300 barrels per day, the oil will be removed at the same rate at which it flows into the well from the formation.

A more accurate determination of the maximum potential production capacity of the well may be made by comparing the fluid pressure at the pump under two different operating conditions of the pump, such as by measuring the fluid pressure at the pump when the pump is operating at one production rate, for example its normal rate, and then changing the rate of production of the pump as by slowing the pump down, changing the stroke of the pump or by building up gas pressure on the liquid surface and plotting the relation between the new production rate and the fluid pressure measured by my method, as set forth herein, it will be found that a line intersecting these two points will also repre-

Defendant's Exhibit Q—(Continued)

sent the relation between production rate and fluid pressure at the pump at any rate of production by the pump. As shown in Fig. 6, the normal production rate of 200 barrels per day plotted against the fluid pressure at the pump in pounds per square inch may be represented upon the chart by the point G while at a reduced rate of production at the pump, say to 100 barrels per day, it will be found that the fluid pressure at the pump is increased so that by determining the fluid pressure under these conditions, the relation between the reduced production rate and the fluid pressure at the pump may be plotted by the point H. A straight line interconnecting the points H and G will intersect the zero pressure ordinate at a point therealong, indicating a maximum possible production of 300 barrels per day. In making such determinations, however, it is desirable that the rate of production of the pump be reduced to at least two thirds of its normal production rate and preferably to 50% of its normal production rate in order to obtain substantially widely separated points H and G.

Again, it will be noted that all of the necessary calculations to determine the maximum production possible of the well may be made without interrupting the normal production conditions at the well and without requiring the laborious efforts of removing and replacing any of the pump mechanisms.

In order to determine the fluid pressure at the pump in most producing wells where there is considerable fluid over the pump one, two or more fluid

Defendant's Exhibit Q—(Continued)

level measurements are made by the method described and claimed in the Wyatt et al. patent and in my co-pending applications hereinbefore referred to, from which level determinations the pressure at the pump is determined as described hereinbefore. However, I have discovered that in some wells where the operating fluid level is some distance above the pump and where there is sufficient gas pressure to depress the fluid level to the pump, the pump, when the fluid level reaches or approaches its inlet, will produce a pressure wave and this pressure wave may be detected by a skilled operator by employing either the mechanical or electrical vibration receiving and translating mechanism illustrated in my co-pending applications hereinbefore referred to, the electrical system being illustrated diagrammatically in Fig. 3, wherein a microphone 15 is coupled to the gas outlet pipe 11 to be actuated or vibrated in accordance with pressure waves passing upwardly in the casing 1. The microphone 15 is illustrated as a diaphragm condenser type microphone coupled through a detector-amplifier system 16, the output of which is connected to a galvanometer 17 to move a mirror 18 in accordance with movement of the microphone 15 to reflect a light beam 19 from a suitable source of light 20 upon a screen 21 to describe on the screen a line of light the length of which corresponds to the amplitude of the pressure waves received upon the diaphragm 15.

When the fluid surface is well above the pump there will be observed a regular wavy pulsation of

Defendant's Exhibit Q—(Continued)

the light on the screen but when the level of the fluid is so depressed that the pump takes in a quantity of free gas on each stroke a jerky motion is observed.

Thus, by observing the screen 21, a skilled operator is able to distinguish between fluid surface pulsations caused by the action of the pump and pressure waves produced by the pump when the level of the fluid reaches the pump inlet.

While the pressure waves created at the pump under these conditions may be visually observed with the light beam and screen arrangement shown in Fig. 3, they may be equally as well observed audibly by employing a telephone receiver 22 or other audible translating device coupled to the output circuit shown and described in my co-pending application Serial No. 164,534 herein. By listening at the receiver, a skilled operator may determine the "break" or change of pressure waves occasioned by the level of the liquid approaching the pump inlet.

While a diaphragm type of microphone is shown in Fig. 3, a hot-wire, ribbon or other types of microphones may also be used.

Having this means of knowing when the liquid level is at or near the pump the casing pressure is adjusted to maintain the liquid level a few feet above the pump inlet until the rate of production becomes constant under the increased casing pressure. From the casing pressure required to maintain the liquid level close to the pump the pressure at this level can be determined by adding to the casing pressure the

Defendant's Exhibit Q—(Continued)

pressure on the liquid surface caused by the weight of the gas column above it. (∧C1)

Pump noises at the ground surface have been heard or observed as accompanying a low volumetric efficiency of the pump, indicating that charges of free gas are entering the pump on each stroke. However, it has heretofore been impossible to distinguish between the two conditions which caused them, namely whether the liquid level was so low as to fall to or below the pump inlet on each stroke or whether the pump inlet was located well below the surface but at such point in the liquid column that free gas was entering the pump with the liquid. By employing my method of detecting the waves and then determining the level of the fluid surface, these may readily be distinguished and the pump raised or lowered as is indicated as necessary to correct the trouble.

It will therefore be observed that I have provided a ready method for determining the density of the fluid in any particular well and also for the determination of the fluid pressure at the pump without requiring the removal or alteration of any of the usual mechanism found in the well. It will also be noted that I have provided a ready method for graphically determining the fluid pressure at the pump by first determining the amount of recession of the fluid level due to changes in gas pressure exerted upon the fluid surface and plotting this information upon a graph or chart and extending a straight line intersecting the two or more points so

Defendant's Exhibit Q—(Continued)

located to a point on the chart representing the level of the pump inlet. It will also be noted that I have devised a ready means of utilizing the information obtained with respect to fluid levels and gas pressures at the casing head of the pump for mathematically determining the fluid pressure at the pump and also for utilizing this information to determine accurately the potential production of any well measured. (∧C2)

While I have illustrated and described the preferred embodiment of my invention, I do not desire to be limited to any of the detail illustrated or described herein except as defined in the appended claims.

HWM:SG

I Claim

1. The method of determining the pressure of liquid in a well at the level of the liquid surface therein, which consists in determining the location of the liquid surface and adding to the pressure of the gas at the casing head, the effect in pressure of the column of gas between the liquid surface and the casing head.

2. The method of determining the pressure of liquid in a well at any desired level therein, which consists in changing the pressure of gas on the liquid surface to move the surface to the desired level and adding the pressure at the casing head of the gas required to so located the surface to the effect in pressure of the column of gas between the liquid surface and the casing head.

Defendant's Exhibit Q—(Continued)

3. The method of determining the pressure of liquid in a well at any level below the surface thereof, which consists in allowing the level of the liquid surface to become stable, measuring the location of the liquid surface under stable level condition, noting the pressure of gas upon the liquid surface and computing the desired pressure by adding the gas pressure at the casing head of the well to the effect in pressure of the column of gas between the liquid surface and the casing head and adding the effect in pressure of the column of fluid above the desired level.

4. The method of determining the pressure of liquid in a well at any desired level at or below the surface of the liquid therein, which consists in building up and maintaining gas pressure within the casing of the well until the liquid surface level therein becomes stable, measuring the location of the liquid surface under this stable condition and computing the desired pressure by adding the gas pressure at the casing head of the well to the effect in pressure of the column of gas between the liquid surface and the casing head and adding thereto the effect in pressure due to the column of liquid between the liquid surface and the desired level.

5. The method of determining the pressure of liquid in a well at any level therein at or below the liquid surface while the pump ~~pipe~~ is producing liquid from the well, which consists in allowing the level ~~of the liquid surface to become stable under the pro-~~

Defendant's Exhibit Q—(Continued)

duction rate of the pump, measuring the location of the stable surface level and computing the desired pressure by adding the gas pressure at the casing head of the well to the effect in pressure of the column of gas between the casing head and the liquid surface and adding thereto the effect in pressure of the column of fluid between the stable liquid surface level and the desired level.

6. The method of determining the pressure exerted by the liquid in a well at any level therein, which consists in measuring the stable liquid level in one known condition of gas pressure in the casing of the well, determining the stable level of the liquid in the well under another known condition of gas pressure within the casing of the well, plotting the relations between liquid level and pressure on the liquid surface, extending a straight line intersecting said plotted points and determining the pressure at any level by points on said line representing said desired level.

7. The method of determining the pressure exerted by the liquid in a well at any point below the surface of the liquid which consists in determining the stable level of the liquid under one known condition of pressure of gas within the casing of the well, determining the stable level of the liquid under another known condition of gas pressure within the casing of the well, determining the pressure exerted by the liquid per unit of height of the liquid by comparing the difference in said levels with the difference in pressure required to change said levels

Defendant's Exhibit Q—(Continued)

and adding to the pressure upon the surface of the liquid at either of said levels the product of the height of the surface above the desired level by the unit of pressure so obtained.

8. The method of determining the pressure of liquid in a well at the level of the inlet of a pump in said well which consists in measuring the stable level of the liquid surface under one condition of gas pressure in the casing of the well, measuring the stable level of the surface of the liquid in the well under a different condition of gas pressure in the casing of the well, computing the density of the liquid in the well by dividing the increase in pressure by the distance between the two levels of the surface of the liquid so determined and then adding the sum of the gas pressure in the casing and the pressure exerted by the weight of the column of gas above the liquid surface at one level to the product of the distance between the liquid surface level and the level of the pump inlet and the density of the fluid so obtained.

9. The method of determining the pressure exerted by the liquid in a producing well at any desired level below the level of the surface of the liquid, which consists in plotting the relation between two stable levels of the liquid surface against the stable pressures on the liquid surfaces required to maintain said levels, extending a straight line from said plotted points and determining the pressure at the desired level from the intersection of said line with a plot of the desired level.

Defendant's Exhibit Q—(Continued)

10. The method of determining the pressure of liquid in a producing well at the level of the inlet of a pump therein which consists in building up just the proper amount of gas pressure in the well casing to maintain the liquid level at or preferably a few ^ feet above the level of the pump inlet and computing the desired pressure by adding the gas pressure at the casing head of the well to the effect in pressure of the column of gas between the pump inlet and the casing head.

11. The method of determining the pressure of liquid in a producing well at the level of the inlet of a pump in said well, which consists in depressing the surface of the liquid from its normal level to the level of the pump inlet by gas pressure in the casing of the well and while the pump is operating, determining the arrival of the surface of the liquid at the level of the pump inlet by detecting visually or audibly pressure waves produced by the pump when the level reaches its inlet and then, after the pump has operated a sufficient length of time for all conditions to become stable, computing the pressure at the pump by adding the pressure of the gas at the casing head required to maintain the liquid level at or near the inlet of the pump, to the effect in pressure due to the column of gas between the pump inlet and the casing head.

12. The method of determining when the surface of the liquid in a well is at the level of the pump inlet, which consists in observing the pressure waves

Defendant's Exhibit Q—(Continued)

produced at the pump by the entry of free gas thereto.

13. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in observing the difference in the pressure waves produced in the gas in the casing by the surge of the liquid level caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

14. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in visibly observing the difference in the pressure waves produced in the gas in the casing by the surge of the liquid level caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

15. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in audibly observing the difference in the pressure waves produced in the gas in the casing by the surge of the liquid level caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

16. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in exposing a microphone to the gas in the well casing and observing the difference in the effect upon the microphone under

Defendant's Exhibit Q—(Continued)

~~pressure waves created in the gas by the surge of the~~ liquid level in the well caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

17. The method of determining when the surface of the liquid in a producing well is at the level of the pump inlet, which consists in exposing a diaphragm to the gas in the well casing and observing the difference in the movement of the diaphragm under pressure waves created in the gas by the surge of the liquid level in the well caused by removal of liquid by the pump and those waves produced by the entry of free gas into the pump.

18. The method of determining the static pressure at the inlet of the pump in a well, which consists in closing the casing of the well ∧ ~~to allow~~ and building up the pressure of the gas within the well to depress the level of the liquid therein to a stable level and then locating the stable level of the liquid surface.

19. The method of determining the static pressure at the inlet of the pump in a well, which consists in closing the casing of the well ∧ ~~to allow~~ and building up the pressure of the gas within the well to depress the level of the liquid therein to a stable level, locating the stable level of the liquid surface, and then computing the pressure at the pump inlet by adding to the pressure of the gas at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface and adding thereto the effect in pres-

Defendant's Exhibit Q—(Continued)

sure of the column of liquid between the surface level so determined and the level of the pump inlet.

20. The method of determining the static pressure at any level below the liquid surface of a well, which consists in closing the casing of the well and building up the pressure of ^ ~~to allow~~ the gas within the well to depress the level of the liquid therein to a stable level, locating the stable level of the liquid surface, and then computing the pressure at the desired level by adding to the pressure of the gas at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface and adding thereto the effect in pressure of the column of liquid between the surface level so determined and the level so desired.

21. The method of determining the maximum potential capacity of an oil well which consists in determining the pressure of the liquid at the pump inlet while the pump is operating at one rate of production, by locating the stable level of the surface of the liquid under one condition of gas pressure at the casing head, adding to the pressure at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface, determining the density of the liquid for this rate of production and adding to the sum of the pressures obtained, the effect in pressure of the column of liquid between the liquid surface and the pump inlet, then changing the rate of production and depressing the liquid surface to a point so near to the pump in-

Defendant's Exhibit Q—(Continued)

~~let that the determination of density of liquid under~~ this pressure and rate of production is unnecessary, adding to the pressure of the gas required to so depress the liquid level the effect in pressure of the column of gas between the pump inlet and the casing head, and then comparing the change in production with the change in liquid pressures at the pump inlet and using the ratio thus found to determine the date of production for zero, or any other pressure, at the pump or at other locations normally below the producing level of the liquid in the well.

22. The method of determining the potential production capacity of an oil well, which consists in determining the static or non-producing pressure of the liquid at the pump inlet by closing the casing head, allowing the pressure of the gas escaping from the fluid to depress the surface level of the liquid to a stable condition, locating this level and computing from the pressure at the casing head and the liquid surface level, the pressure at the pump inlet, determining the pressure at the pump inlet when the pump is operating at a predetermined production rate by locating the liquid surface level when the pump is so operating and computing from the pressure of the gas at the casing head and the second level so obtained, the second pressure of the liquid at the pump inlet and comparing the two pressures of the liquid at the pump inlet to determine the production capacity of the well at zero pressure of the liquid.

Defendant's Exhibit Q—(Continued)

23. The method of determining the potential production capacity of an oil well, ($\wedge C^7$) which consists in determining the static, or non-producing pressure of the liquid at the pump or at any other desired location near the bottom of the well by closing the casing head, allowing the pressure of the gas escaping from the liquid to depress the surface level of the liquid to a stable condition, locating this level and from the known gas and fluid gravities and the pressure at the casing head computing the pressure at the pump inlet or other location near the bottom of the well; determining the pressure at the pump inlet or other location near the well bottom at a predetermined production rate by locating the liquid surface level when the pump is so operating, adding to the pressure at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface, determining the density of the liquid for this rate of production and adding to the sum of the pressures obtained, the effect in pressure of the column of liquid between the liquid surface as determined and the pump inlet or other location near the bottom of the well, comparing the difference between the static and operating pressures so determined at the pump, or other location near the bottom of the well, with the operating rate of production for the test and using the ratio thus found to determine the production capacity for zero, or any other pressure at the pump inlet or at other locations normally below the producing level of the liquid in the well.

Defendant's Exhibit Q—(Continued)

24. The method of determining the potential production capacity of an oil well, ($\wedge C^7$) which consists in determining the pressure of the liquid at the pump inlet or other location near the bottom of the well while the pump is operating at one rate of production by locating the stable level of the liquid surface under one condition of gas pressure at the casing head, adding to the pressure at the casing head the effect in pressure of the column of gas between the casing head and the liquid surface, determining the density of the liquid for this rate of production and adding to the sum of the pressures obtained the effect in pressure of the column of liquid between the liquid surface and the pump inlet or other location near the bottom of the well; changing the rate of production by altering the speed of operation of the pump, the length of the pump plunger stroke, or by changing the casing pressure, then repeating the operations and calculations made for determining the pressure at the pump or other location near the bottom of the well for the first rate of productions; then comparing the change in production with the change in liquid pressure at the pump inlet or other location near the bottom of the well and using the ratio thus found to determine the rate of production for zero, or any other pressure, at the pump inlet or at other locations normally below the producing level of the liquid in the well.

25. The method of determining the potential production capacity of an oil well, ($\wedge C^8$) which con-

Defendant's Exhibit Q—(Continued)

sits in determining the liquid pressure at or near the pump inlet when the pump is operating at its normal or any other rate of production, reducing the production rate of the pump by increasing the gas pressure in the casing to depress the liquid level until the liquid surface level attains a suitable condition adjacent the inlet of the pump, computing the pressure on the surface of the liquid at the new level and comparing the change in production with the change in liquid pressures at the pump inlet and using the ratio thus found to determine the rate of production for zero, or any other pressure at the pump or at other locations normally below the producing level of the liquid in the well.

26. The method of determining the density of liquid in a well (∧C9) which consists in measuring annular space between the pump tubing and the casing the fluid level in the ∧ ~~well~~ under one condition of gas pressure in the well, changing the gas pressure in the well and measuring the stable fluid level under the new gas pressure conditions and comparing the on the liquid surface increase in pressure ∧ with the change in fluid level.

27. The method of determining the density of liquid in a well (∧C9) which consists in measuring annular space between the pump tubing and the casing the level of the surface of the liquid in the ∧ ~~well~~ under one condition of gas pressure in the well, depressing the fluid level to a new location by changing the pressure of the gas in the well and compar-

Defendant's Exhibit Q—(Continued)

~~on the liquid surface~~

ing the increase in pressure ∧ required to achieve the new stable level with the difference in stable levels of the liquid surafce.

28. The method of determining the density of the liquid in a well (∧C10) which consists in deter-

annular space between the
pump tubing and the casing

mining the liquid level in the ∧ ~~well~~ under one condition of pressure, changing the pressure of the gas within the well to move the liquid surface to a new stable level, measuring the new level and dividing the change in pressure on the fluid surface to achieve the new level by the difference between the two levels.

29. The method of determining the density of liquid in a well (∧C10) which consists in measuring

annular space between the
pump tubing and the casing

the fluid level in the ~~well~~ ∧ while the pump therein is operating under a known condition of gas pressure on the surface of the liquid in the well, changing the gas pressure on the liquid surface in the well, continuing the operation of the pump until the liquid level therein becomes stable at a new location and comparing the difference in the pressures exerted on the liquid surface at the two levels with the difference in feet of the two levels.

30. The method of determining the density of fluid in a well (∧C10) which consists in employing the gas produced in the well to hold the liquid sur-

Defendant's Exhibit Q—(Continued)

face in the ∧ ~~well~~ annular space between the pump tubing and the casing at two different levels and comparing the difference in the pressures exerted by the gas on the liquid surface at the two levels with the difference in feet between the two levels.

31. The method of determining the density of liquid in a well (∧C11) which consists in measuring the level of the surface of the liquid under one condition of pressure of the gas released by the well, regulating the flow of gas from the well to increase the pressure of said gas to a different value and comparing the difference in the pressures exerted upon the liquid surface under the two conditions of gas pressure with the difference in feet of the levels of the liquid surface under the two pressure conditions.

32. The method of determining the density of liquid in a well (∧C11) while it is producing normally, which consists in depressing the level of the surface of the liquid to two or more known stable locations, determining the stable pressure on the liquid surface at the two locations and comparing the difference in feet between any two levels with the pressure required to change the liquid level from one location to the other.

33. The method of determining the density of liquid in a well (∧C12) which consists in determining the stable level of the liquid in the ∧ ~~well~~ annular space between the pump tubing and the casing under one stable condition of gas pressure in the casing

Defendant's Exhibit Q—(Continued)

~~of the well, depressing or elevating the liquid level~~ in the well by increasing or decreasing the pressure of the gas within the casing of the well, determining the new stable liquid level and then comparing the difference between the difference between the two stable levels with the pressures exerted on the liquid surface by the gas under the two stable pressure conditions.

34. The methods of determining the density of the liquid, the liquid pressure at any level and the maximum potential production capacity in an oil ~~well substantially as shown and described herein.~~

In Testimony Whereof I affix my Signature
(Sign here first name in full)

CRANFORD P. WALKER.

OATH

State of California,
County of Los Angeles—ss:

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of San Marino, California; that he verily believes himself to be the original, first and sole inventor or discoverer of the Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells described and claimed in the annexed specifications; that he does not know and does not believe that the same was ever known or used before his invention

Defendant's Exhibit Q—(Continued)

or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said invention has been filed by him or his legal representatives or assigns in any country foreign to the United States.

(Sign here, first name in full)

CRANFORD P. WALKER.

Subscribed and sworn to before me, this 20th day of October, 1937.

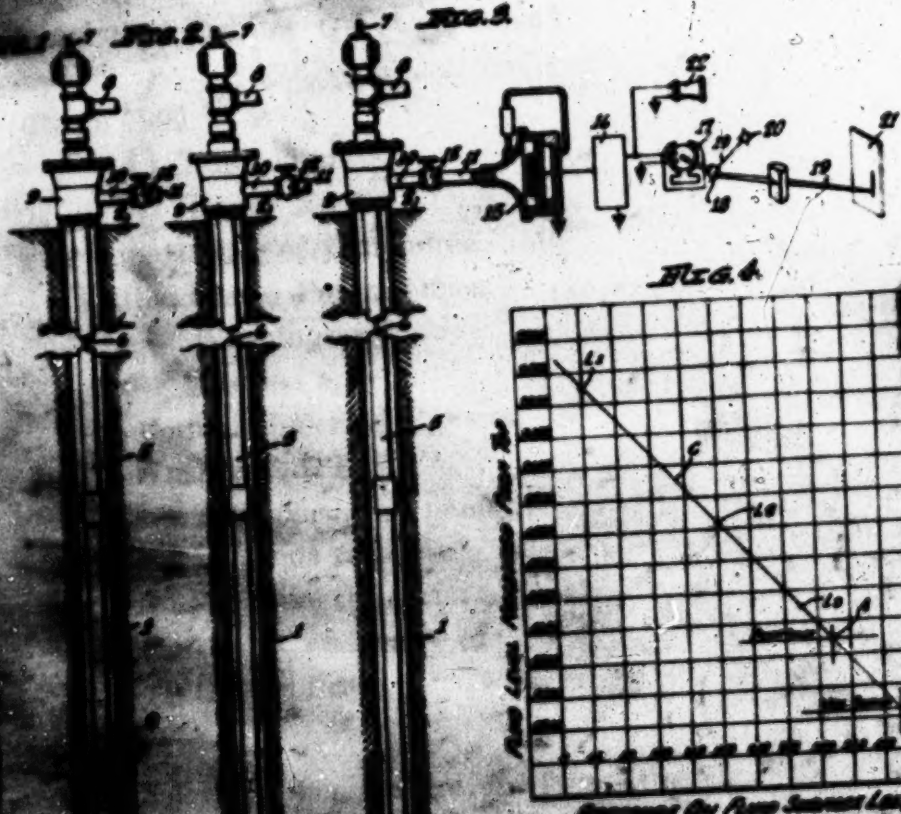
(Seal) } MARJORIE McKAY,

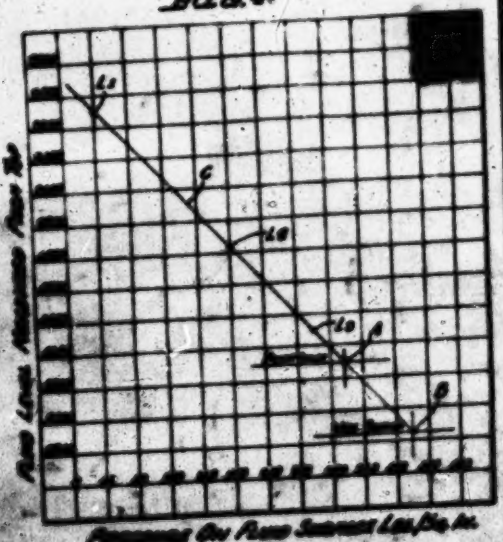
Notary Public in and for said County and State.

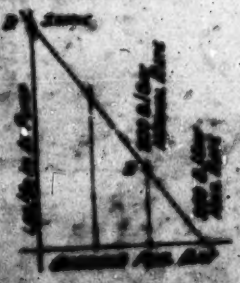
My Commission Expires July 14, 1941.

171170

Print of drawing as originally filed.







INVENTOR:

ATTORNEY.

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171170

Defendant's Exhibit Q—(Continued)

260

Div. 36 Room 7892

Buchler:mwc
Paper No. 3
Department of Commerce
United States Patent Office
Washington
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Mailed Feb 5 1938.

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE
Commissioner of Patents,

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937
For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Defendant's Exhibit Q—(Continued)

This application has been examined.

The following references, the result of a cursory search, are cited to show classification of the groups of the requirement for division stated below:

Lehmann,	1,960,158,	May 22, 1934,	(73-31-6);
et al,	3,047,974,	July 21, 1936,	(177-352.6);
Doherty,	1,899,497,	Feb. 28, 1933,	(166-21);
Hay,	2,056,187,	Oct. 6, 1936,	(265-44);

How does Applicant know that the lines connecting points D and E in Fig. 5 and the line connecting points G and H in Fig. 6 will be straight lines? For instance, Figs. 5 and 6 indicate that, at zero pressure at the pump inlet, the capacity is 300 barrels per day. Assuming the pump to be pumping 300 barrels per day, it would seem that there would be a substantial pressure at the pump inlet due to the gas pressure in the well. Thus, it would seem that line DE or HG would never intersect the zero pressure line.

In Fig. 3, is not casing 1 shown as being sealed from the oil below the pump? If so, how may oil rise in casing 1?

In line 21 of page 2, "any" should be <u>may</u>.

In line 12 of page 14, "pressure" should apparently be pluralized.

Apparently the comma in line 24 of page 17 should be a semi-colon.

In line 8 of page 19, <u>and</u> should be inserted before "the".

Claims 1 to 34, inclusive, are in the case.

The claims are drawn to four distinct and independent inventions. Thus:

Defendant's Exhibit Q—(Continued)

I. Claims 1 to 11, both inclusive, 18, 19 and 20 cover a process of measuring pressure and would be classifiable in Class 73, Sub. 31 in Div. 36 as indicated by the above cited patent to Lehmann.

II. Claims 12 to 17, both inclusive, cover a process of determining the level of liquid in a well and would be classifiable in Class 177, Sub. 352 in Div. 42 as indicated by the above cited patent to Lehr et al.

III. Claims 21 to 25, both inclusive, cover a method of determining the potential production capacity of an oil well and would be classifiable in Class 166, Sub. 21 in Div. 38 as indicated by the above cited patent to Doherty.

IV. Claims 26 to 33, both inclusive, cover a method of determining density and would be classifiable in Class 265, Sub. 44 in Div. 36 as indicated by the above cited patent to Hay.

Division between these groups is required in accordance with Rule 42, Rules of Practice. Applicant must limit his claims to a single invention. The above cited patents show that the four devices have acquired independent status.

Claim 34 is rejected as failing to "particularly point out and distinctly claim" the invention as required by Section 4888, Revised Statutes.

After election, the statement of objects should be restricted to the subject matter of the invention, the claims to which Applicant elects to prosecute.

A. D. McFADYEN
Examiner.

Defendant's Exhibit Q—(Continued)

Application Div. Apr 25 '38 U. S. Patent Office.
U. S. Patent Office Apr 26 1938 Division 36

In the United States Patent Office
Division 36 — Room 7892

Cranford P. Walker,

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells,

Filed October 26, 1937,
Serial No. 171,170.

Los Angeles, California,
April 18, 1938.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

In response to the Office action of February 5, 1938, please amend the above identified application as follows:

Page 2, Line 21, change "any" to read —may—.

Page 14, Line 12, pluralize the word "pressure".

Page 17, Line 24, change the comma to a semicolon.

Page 19, Line 8, before "the" insert —and—.

Claim 5, Line 3, change "pipe" to read —pump—.

Claim 10, Line 5, change "feed" to read —feet—.

Claims 18, 19 and 20, Line 3, change "to allow" to read —and building up the pressure of—.

Cancel Claim 34.

Defendant's Exhibit Q—(Continued)

REMARKS

With reference to the question raised by the Examiner in the second paragraph of the last Office action as to how the applicant knows that the lines connecting points D and E in Fig. 5 and the line connecting points G and H in Fig. 6 will be straight lines, it is a peculiar characteristic of most oil wells observed by the applicant that in plotting actual measurements of pounds per square inch against the production in barrels per day, as described in the specification of this application, the various points which are plotted are found to be substantially in a straight line so that projection of a straight line intersecting two or more of the points plotted, as indicated in Figs. 5 and 6, will permit the determination of the ratio in barrels per day against pressure at the pump for any other values of pump pressure. Careful plottings of these values over a considerable period of time show that any variation of the actual values from such straight line are so small as to be negligible.

The intersection of the line D and E with the zero pressure line represents a theoretical operation of a pump at such speeds and such stroke as to balance the pressure of the gas and of the oil within the well so that the pump is removing the oil from the well at the same rate at which the oil is flowing into the well from the sand. In other words, if a pump should be so operated as to remove the oil at exactly the same rate at which the oil flows into the well, a

Defendant's Exhibit Q—(Continued)

condition of zero pressure at the pump inlet would result. Many oil wells are now being operated at from only 5 to 15 pounds of casing pressure while in certain oil districts, such as Signal Hill in California, pumps are being operated with as much as 22 inches vacuum or a sub-zero pressure. With a casing pressure of 1 pound on a well 5000 feet deep and containing heavy gas, the pressure at the pump under such conditions would be only 3 pounds per square inch or less, that is, substantially zero pressure at the pump inlet.

The statements made in the specification relative to the points D-E and H-G lying in a straight line and that for other values of pump pressure the plotting of the barrels per day would lie along such straight line is not the mere propounding of a theory by the applicant but is the result of actual calculations based upon experiment, measurement and calculation. In answer to the Examiner's criticism of Fig. 3 of the drawing, the casing 1 is not sealed from the oil below the pump, there being represented diagrammatically in this drawing a screen liner at the bottom of the well into which the pump projects, the liner sealing with the casing, but the pump and its tubing extend down into the liner with considerable space between the exterior of the pump and the interior of the liner. This is common oil well pump practice and if there is any possibility of misunderstanding of the showing in the drawing, the applicant will be pleased to amplify the illustration as by breaking the liner and showing the same in

Defendant's Exhibit Q—(Continued)

section to illustrate the manner in which the pump and tubing are spaced from the liner. The Examiner's suggestion along this line will be appreciated.

Reconsideration of the requirement for division is respectfully requested. The applicant has disclosed in this application the method for making a series of calculations necessary and desirable for the most efficient production from oil wells and each of the claims is directed to a method for measuring and determining certain desired values necessary to be obtained and to be used for the efficient operation of wells.

While it is true that there are disclosed several uses for the information which is obtained, all of these uses are related to each other for producing desired oil well characteristic information.

One generic characteristic may be observed in all of the claims, namely, that the production of the information and the determination of all of the values depends upon observing the location of the level of the liquid surface in the well.

The claims which the Examiner has indicated should be grouped as Group I are all directed to the method of determining the pressure at any desired level in the column of liquid in the well; the method of determining the potential capacity of the well, claims to which the Examiner has grouped as Group III, depend upon first determining the pressure at any desired level in the liquid column, such determination being made by the method defined in the

Defendant's Exhibit Q—(Continued)

claims of Group I; the determination of the density of the liquid, claims to which the Examiner has grouped in Group IV, are likewise based upon first determining the liquid level in the well by the steps included in the determination of the pressure as defined in Group I.

As to Group II, it is believed that these claims are "sub-combination claims" under Group I rather than independent of Group I since each of these claims is addressed to a determination of the pressure of the liquid at a predetermined level in the well, namely, the inlet of the pump, and the method which is followed to obtain this information constitutes either (a) the observation of the fact that the liquid level is at the pump inlet, or (b) depressing the liquid level to the pump inlet and determining when the level has arrived at this point.

It will therefore be seen that all of the claims are addressed to such interrelated and interdependent subject matter that to require the applicant to divide this case into four parts as indicated by the Examiner, would not only work an entirely unnecessary hardship upon the applicant but would result in the separate classification of the different groups of claims in different classes when all of these claims should be classified in the same class.

The art which the Examiner has cited to indicate the probable classification of the several groups of claims does not show that these groups would be entirely classifiable as indicated by the Examiner.

Defendant's Exhibit Q—(Continued)

The patent to Lehmann is not directed to a method of determining liquid pressure in oil wells and to classify the claims of Group I (and II) in the same class with the Lehmann invention would be to place them in a field of search entirely foreign to the essence of the applicant's invention as expressed in these claims.

The patent to Doherty, cited to indicate proper classification of the claims of Group III, is not directed to a method for determining the production capacity of an oil well but instead is directed to a method of operating an oil field, there being no relation or similarity of any character between the subject matter of the Doherty patent and the subject matter of the claims of Group III.

The patent to Hay, cited to show classification of the claims of Group IV, discloses a piece of apparatus which may be used to measure the specific gravity of a small quantity of liquid placed in a container of predetermined size but does not show and has no relation to a method of determining the density of oil at a certain level within an oil well under the conditions existing in the well.

It is interesting to note that at this point there appears to be some doubt as to the proper classification of methods and apparatus for measuring liquid level, liquid pressure, density and production capacity in oil wells, the applicant having on file three applications directed to these problems, the generic feature of all of which is the determination of the liquid level and yet each of these three applications

Defendant's Exhibit Q—(Continued)

has been assigned to a different division and to a different class, namely, the present application No. 171,170 has been assigned to Division 36, application No. 162,699, filed September 7, 1937, has been assigned to Division 5, while application No. 164,534, filed September 18, 1937, has been assigned to Division 42.

The patent to Lehr, et al. which has been cited by the Examiner as indicative of proper classification of the claims of Group II, would appear to be representative of the proper classification for all of these applications and all of the claims in the present application since the claims of the Lehr, et al. patent more nearly represent the character and type of invention to which all of these applications are addressed.

It is believed that upon reconsideration of this requirement for division, it will be found that all the claims of this application are properly classifiable in a single class and are examinable in the same field of search.

In view of the fact that the first Office action in this case consisted solely of a requirement for division, it is believed that this application should be taken up for special action and that an early action upon the merits should be entered therein.

Respectfully submitted,

HAROLD W. MATTINGLY
Attorney for Applicant.

HWM:MM

Defendant's Exhibit Q—(Continued)

7892—#5

June 16, 1938

In re application of:
Cranford P. Walker
Ser. No. 171,170
Filed: Oct. 26, 1937

For: Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Examiner, Division 36:

Division has been required among:

I. Claims 1-11, 18-20;
II. Claims 12-17;
III. Claims 21-25, and
IV. Claims 26-33.

Division is disapproved at present among groups I, III and IV since they are not distinct. There is considerable overlapping between the claims in these groups and they should be combined. The claims of group II are distinct from the remaining claims and the inventions covered thereby are not limited to use in the methods of the other claims. In re Ferenci, 1936 C. D. 373 and 445.

Division between:

I. Claims 1-11, [illegible]-33 and
II. Claims 12-17

is approved.

Respectfully,
B. E. LANHAM
Associate Examiner,
Classification Division.

BEL:AF

Defendant's Exhibit Q—(Continued)

#6

In the United States Patent Office

U. S. Patent Office Apr 28 1938 Division 36.

Application Div. Apr 28 '38 U. S. Patent Office.

In re Application of
Cranford P. Walker
Serial No. 171,170
Filed October 26, 1937

Method of Determining Fluid Density, Fluid Pressure and the Producing Capacity of Oil Wells

Los Angeles, Calif., April 19, 1938.

ASSOCIATE POWER OF ATTORNEY

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Please recognize Raymond Jones, of 1427 Eye Street, N. W., Washington, D. C., as associate in the above entitled application. Send all correspondence to attorney of record.

Respectfully,

HAROLD W. MATTINGLY
Attorney of Record.

HWM:WN

Defendant's Exhibit Q—(Continued)

260

Div. 36 Room 7892

Buchler/Bu

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Paper No. 7

All communications respecting this application should give the serial number, date of filing, and name of the applicant

Mailed Jun 20 1938

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE

Commissioner of Patents,

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937
For Method of Determining Fluid Density, etc.

In response to amendment filed April 25, 1938.

With regard to Fig. 3, there is apparently shown

Defendant's Exhibit Q—(Continued)

a collar surrounding tubing string 5, which collar is about two inches above the bottom end of the screen in Fig. 3. This collar, as shown in Fig. 3, appears to prevent communication between the space in the casing 1 above and below the collar. If this collar is merely a spider, it would apparently be sufficient merely to state this fact.

Claims 1 to 33, inclusive, are in the case.

The requirement for division has been submitted to the Examiner of Classification who states:

"Division has been required among:

I. Claims 1-11, 18-20;
II. Claims 12-17;
III. Claims 21-25, and
IV. Claims 26-33.

Division is disapproved at present among groups I, III and IV since they are not distinct. There is considerable overlapping between the claims in these groups and they should be combined. The claims of group II are distinct from the remaining claims and the inventions covered thereby are not limited to use in the methods of the other claims. In re Ferenci, 1936 C. D. 373 and 445.

Division between:

I. Claims 1-11, 18-33 and
II. Claims 12-17

is approved."

Therefore with the approval of the Examiner of Classification, the requirement for division between

(I) Claims 1 to 11, inclusive, and 18 to 33, inclusive, and

Defendant's Exhibit Q—(Continued)

(II) Claims 12 to 17, inclusive is now MADE FINAL.

A. D. McFADYEN
Examiner

#8

U. S. Patent Office Jul 11 1938 Division 36.
Mail Division Jul 9,1938 U. S. Patent Office.

In the United States Patent Office
Division 36
Room 7892

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Filed: October 26, 1937
Serial No. 171,170

Los Angeles, California
July 5, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of June 20, 1938, the applicant herein elects to prosecute claims 1 through 11 and 18 through 33 in the present application and under the provisions of Rule 42, it is requested that claims 12 through 17, not elected, be retained in this case for the purposes of appeal.

The Examiner's criticism of Fig. 3 of the drawings is believed to be due to a misunderstanding of

Defendant's Exhibit Q—(Continued)

the parts illustrated therein. The lower end of the casing 1 is illustrated as having attached thereto a "perforated liner" which is secured to the casing as by means of the collar referred to by the Examiner. It will be appreciated that this collar has an internal diameter in excess of the external diameter of the tubing 5 or the pump 4 so that the tubing and pump may extend through the collar and into the liner and yet provide an annular space therebetween completely surrounding the pump and tubing. This space will readily permit the pressure impulses to pass down between the pump tubing and the liner, although a distinct echo will be produced by the top or collar of the lining as indicated in the graphs of the measurements made by the applicant's instrument as disclosed in his co-pending application, Serial No. 162,699, referred to in the body of this specification (now being examined in Division 5).

If, in view of the foregoing explanation, the Examiner feels that this collar and its arrangement should be more amply described in the specification, the applicant will be pleased to do so, but since this forms no part of the present invention and is merely a diagrammatic illustration of a well known and common practice in the industry, it is not believed such detailed description is necessary.

In view of the foregoing election, which has been made promptly in response to the Office action, and in view of the fact that no action on the merits of

Defendant's Exhibit Q—(Continued)

this application has been made up to the present time, it is believed that this application should be made special for the next Office action, under Commissioner's Order 2670, and an early, favorable action on the merits is requested.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant

HWM mm

#9—B

Application Div. Oct 15 '38 U. S. Patent Office.
U. S. Patent Office Oct 17 1938 Division 36.

In the United States Patent Office
Division 36 — Room 7892

Cranford P Walker
Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells,

Filed October 26, 1937
Serial No. 171,170

Los Angeles, California
October 4, 1938

Hon. Commissioner of Patents
Washnigton, D. C.

Sir:

Supplementing the amendment of July 5, 1938, please amend the above identified application as follows:

Defendant's Exhibit Q—(Continued)

Page 3, Line 26, change "taking" to read —making—.

Please add the following claims:

~~35. The method of determining the potential~~ production capacity of an oil well having a mechanical pump therein and without requiring removal of the pump parts, which consists in determining the location of the liquid level under one stable rate of production by said pump, computing the effect in pressure of the height of the liquid column between said level and some known location below the liquid surface; changing the rate of production by said pump by altering the speed or length of stroke of said pump; determining the level of the liquid under the new rate of production when stabilized, computing the pressure effect of the height of the liquid column between its new level and said known location; comparing the change in liquid pressure at said known location and using the ratio thus found to determine the rate of production for any other pressure at said known location.

—36. The method of determining the potential production capacity of an oil well having a mechanical pump therein and without requiring removal of the pump parts, which consists in locating the liquid level under one condition of production by said pump; altering the production rate of said pump and locating the liquid level under said new rate of production of said pump, comparing the two fluid levels so determined and using the ratio thus found ~~to calculate the rate of production when the fluid~~

Defendant's Exhibit Q—(Continued)

level is at the inlet of the pump or at any other location below said test levels.

—37. The method of determining the potential production capacity of an oil well having a mechanical pump therein and without requiring removal of the pump parts, which consists in locating the level of the liquid surface when the pump is idle, operating the pump at some actual producing rate, locating the level of the liquid surface under said actual producing rate of production of said pump, comparing the two fluid levels so determined and using the ratio thus found to calculate the fluid rate when the fluid level is at the inlet end of the pump or at any other locations below said test levels.

—38. The method of determining the potential capacity of an oil well having a mechanical pump therein and without requiring removal of the pump parts, which consists in determining the static pressure at the pump or other known location below the surface of the fluid by locating the level of the liquid surface when the pump is idle, computing the effect in pressure of the height of the column of liquid between said level so located and the inlet of the pump or other known location; operating the pump at one rate of production thereof and locating the stable liquid level under that rate of production, computing the effect in pressure of the height of the column of liquid between the new level so located and the inlet of the pump or other known location, comparing the difference between said pressures with the difference in the two fluid levels and using

Defendant's Exhibit Q—(Continued)

~~the ratio so found to calculate the rate of produc~~ tion for zero or ~~any other~~ pressure at the pump ~~inlet or said other known location.~~

REMARKS

The new claims submitted herewith have been drawn upon a review of this application to cover certain features of the applicant's invention peculiarly adapted for certain wells.

As was explained in the specification, the determination of the maximum production capacity of an oil well has been discovered by the applicant to be in substantially direct proportion to changes in the location of the fluid level or to changes in the operating pressure at the pump or some other location below the normal liquid level in the well. Where the well is making a considerable quantity of gas and the effect of this gas is to produce a pressure upon the liquid surface, the effect in pressure of this gas must be taken into consideration in order that the calculations produce an accurate result. Also under such conditions of wells making large quantities of gas, the density of the liquid (which varies with the amount of gas made by the well and with the level at which the calculations are to be computed) must also be taken into consideration. However, many wells make little or no gas so that the effect of gas pressure may be disregarded and likewise the density of the liquid may be assumed to be the gravity of the liquid as measured at the ground surface.

Defendant's Exhibit Q—(Continued)

It has been the applicant's discovery that there is a direct ratio between the location of the liquid level under two different rates of production from the pump, whether zero production from the pump (static conditions) and some other producing rate from the pump or between two different producing rates of the pump, and that this ratio is constant for other rates of production and the corresponding stable levels of the liquid. This may be stated and employed in calculations either in terms of ratio of liquid level or in terms of pressure beneath the surface of the liquid. It is therefore believed that the applicant is entitled to claims of the character now inserted.

Claim 35 defines this subject matter as including the steps of locating the liquid level at different rates of production of the pump and computing the effect in pressure of the liquid column above either the pump inlet or other known location below the liquid surface to determine the pressures at the known location or pump inlet under the two operating conditions and employing the ratio of such pressures as illustrated particularly in Figs. 5 and 6.

Claim 36 defines this subject matter in terms of liquid level wherein the density of the liquid, being known, and the effect in gas pressure being so nearly zero as to be negligible, the calculation of the maximum production capacity may be made merely by using the ratio of the two liquid levels at different rates of production, which may be either zero and another rate or two rates above zero.

Defendant's Exhibit Q—(Continued)

Claim 37 defines the same subject matter as Claim 37, but is specific to the utilizing as one of the "production rates", the zero production rate or static condition in the well.

Claim 38 defines the same subject matter as Claim 35, but, like Claim 37, is specific to utilizing as one of the production rates the zero production rate or static condition of pressure in the well.

It is respectfully requested that these claims are clearly allowable and an early favorable action upon all of the claims in this application is respectfully requested.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant.

HWM:MM

Defendant's Exhibit Q—(Continued)

Div. 36 Room 7892

260

Buchler:mwc

Paper No. 10

Mailed Nov 1-1938.

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All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,
Commissioner of Patents.

Harold W. Mattingly,
924 Pacific Finance Bldg.,
631 S. Hope St.,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937

For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

Defendant's Exhibit Q—(Continued)

Responsive to amendment filed October 5, 1938.

Additional references cited and relied upon for rejection:

An article entitled "Bottom-hole Pressures in Oil Wells" by C. V. Millikan and Carroll V. Sidwell on pages 194 to 206, inclusive, of the 1931 volume of the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y., (Copy in Library of Congress, Washington, D. C. Call number TN 860 A4);

An article entitled "Density of Oil-gas Columns from Well Data" by W. V. Vietti, on pages 215 to 220 of the 1931 volume of the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D. C. Call No. TN 860 A4);

An article entitled "Subsurface Pressures in Oil Wells and Their Field of Application" by D. G. Hawthorn on pages 148 to 169 of the 1933 volume 103 of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Li-

Defendant's Exhibit Q—(Continued)

brary of Congress, Washington, D. C., Call No. TN 860 A4);

An article entitled "Determination and Application of Depth Pressures in the Yates Field" by Dale Nix on pages 353 to 366 of the 1932 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D. C.);

An article entitled "Measurements of Original Pressure, Temperature and Gas-Oil Ratio in Oil Sands" by K. C. Sclater and B. R. Stephenson of Ponca City, Oklahoma, said article being found on pages 119 to 136 of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, 1928, 1929, Petroleum Division, Published by the Institute, supra, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D. C.);

Staneliffe,	1,457,406,	June 5, 1923,	(265-44);
Field,	1,519,609,	Dec. 16, 1924,	(");

Additional references cited for Applicant's information:

Rockliff,	503,330,	Aug. 15, 1893,	(73-31-5uxr);
Dexter,	1,100,867,	June 23, 1914,	(73-31-6 xr);
Rathbone,	1,406,682,	Feb. 14, 1922,	(73-51 Oil Well);
Doherty,	1,899,497,	Feb. 28, 1933,	(73-31-6 uxr);

Defendant's Exhibit Q—(Continued)

Subkow,	1,907,608,	May 9, 1933,	(73-31-5 xr);
Foran et al,	2,082,329,	June 1, 1937,	(73-51 Oil Well);
Collins,	1,822,203,	Sept. 8, 1931,	(73-31-5 uxr);
Dunn et al,	1,946,575,	Feb. 13, 1934,	(166-1 uxr);
Wolf,	2,115,379,	Apr. 26, 1938,	(73-151 xr);
Marx,	1,955,855,	Apr. 24, 1934,	(166-1 uxr);

An article entitled "Reservoir Pressure in the Hobbs Field, New Mexico" by R. S. Christie on pages 342 to 352 of the 1932 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division, published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D. C.);

An article entitled "Increasing Ultimate Recovery of Oil" by S. F. Shaw on pages 178 to 188 of the 1931 Volume of Transactions of American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, Petroleum Division. Published by the Institute, 29 West 39th St., New York, N. Y. (Copy in Library of Congress, Washington, D.C.);

The drawing should show a pressure gage connected to the casing head.

Claims 1 to 33 and 35 to 38 are in the case.

Since claims 12 to 17, inclusive, cover an invention not elected, these claims are not examined in this action. Claims 12 to 17 should be disposed of before the time of allowance.

Defendant's Exhibit Q—(Continued)

Claims 1 to 10, inclusive, 19 and 20 are rejected as covering the obvious steps of determining the pressure at the liquid surface in a well.

Claims 1 to 5, inclusive are further rejected as fully met by the above cited article from the 1928-1929 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, particularly pages 124 and 135. The matter at the top of page 124 and at the bottom of page 135 teach the method claimed.

In line 6 of claim 2, "located" should be locate.

Claim 3 is rejected as indefinite since it is not apparent what column is meant by "column of fluid" of the last step.

Claim 3 is further rejected as indefinite. If the gas pressure upon the liquid surface is noted, as stated in the third step, why is it necessary to compute such pressure, as stated in the fourth step?

Claim 8 is further rejected as incomplete because line 11 fails to state that the pressure is measured at the casing head.

Claims 1 to 10, inclusive, 19, and 20 are further rejected as failing to define inventions which fall within one of the statutory classes of invention named in Section 4886, Revised Statutes. Claims 1 to 5, 7, 8, 10, 19 and 20 merely cover computing methods. Claims 6 and 9 merely cover a method of making a drawing.

Claim 18 is rejected as unpatentable over Lehr et al, of record. Anyone has a right to use the device of Lehr et al to measure any liquid level in a

Defendant's Exhibit Q—(Continued)

well. Therefore, it would not be invention to use the device of Lehr et al to determine the stable liquid level in a well.

Unless Applicant can point out a basis in the description for the step in lines 12 to 16 of claim 21, the description should be amended to provide a more definite basis for claim 21.

Claim 22 is rejected as incomplete because the last step of comparing the pressures is insufficient to determine the potential production capacity.

Claim 22 is further rejected as incomplete because the last step fails to state that the zero pressure is at the pump inlet.

Claims 23 and 24 are rejected as broader than the invention because each states that the pressures may be measured "at any other location near the bottom of the well".

Claims 26 to 33, inclusive, are rejected as covering the obvious way of measuring density.

Claims 26 to 33, inclusive, are further rejected as failing to define inventions which fall within one of the statutory classes of invention named in Section 4886, Revised Statutes. These claims merely state a method of computation.

Claims 26 to 33, inclusive, are further rejected as unpatentable over Hay, of record, or Stancliffe, supra, or Efeld, supra. Each of these patents teach that the density of a liquid may be determined by measuring the pressures at two spaced locations in the liquid. In view of such teachings, it would not

Defendant's Exhibit Q—(Continued)

be invention to determine the density of the oil in a well by dividing the difference in pressures at two locations by the distance between such locations.

Unless Applicant can point out where the description states that the pump is operated during the determination of density, the description should be amended to provide a more definite basis for claim 29.

Claim 33 is rejected as incomplete because lines 8 and 9 fail to state that the difference in pressure is utilized.

Claims 35 and 38 are rejected as involving new matter because the original description failed to state capacity of a well could be determined merely from the pressures due to liquid columns.

Claims 35 and 38 are further rejected as involving new matter because the original specification failed to state that "the rate of production for any other pressure" could be determined merely from the ratio of two pressures.

Claims 36 and 37 are rejected as involving new matter because the original specification failed to disclose that the potential production capacity of a well could be determined by merely comparing two fluid levels.

Claims 35, 36, 37 and 38 are further rejected as failing to define inventions which fall within one of the statutory classes of invention named in Section 4886, Revised Statutes. These claims merely state steps of computing.

Claims 36 and 37 are further rejected as unpat-

Defendant's Exhibit Q—(Continued)

entable over Lehr et al, of record. It would not be invention to use the device of Lehr et al to determine the liquid levels in a well under two rates of production for the purpose of determining potential capacity.

Claim 38 is further rejected as involving new matter because the original specification failed to state that the potential capacity of the well could be determined from pressures at "other known location below the surface of the fluid".

Claim 38 is further rejected as indefinite. Why is the static pressure at the pump determined, as stated in the first step, when this static pressure is not used to compute the potential capacity?

Claims 21 and 25 are rejected and claims 22, 23 and 24 are further rejected as failing to define inventions which fall within one of the statutory classes of invention named in Section 4886, Revised Statutes. These claims merely state steps of computing and are therefore not within one of the statutory classes of invention entitled to patent protection.

Claim 21 is further rejected as incomplete because line 16 fails to state that the pressure is at the casing head.

Claim 22 is further rejected as incomplete since sufficient steps are not included for determining the pressures. Merely measuring the casing head pressure and the liquid level is not sufficient to determine the pressures.

Defendant's Exhibit Q—(Continued)

Claims 21, 23, 24 and 25 are further rejected as misleading and broader than the invention because each states, in the last three or four lines, that the rate of production is determined "at other locations . . .".

Unless Applicant can point out where the description provides a basis for the second step of claim 25, the description should be amended to provide such basis.

Claims 26 and 27 are further rejected as incomplete since each fails to state that the pressures are measured at the liquid surfaces.

Claims 36 and 37 are further rejected as involving new matter since the original specification failed to state how the rate of production "at any other location . . ." could be determined by comparison of two fluid levels.

Claims 1 to 5, inclusive, 10, 19 and 20 are further rejected as fully met by page 194 of the 1931 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Division, supra.

Claims 7 and 8 are further rejected as unpatentable over pages 194 and 216 of the 1931 volume and page 150 of the 1933 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Division, supra. It would not be invention to obtain the density of the liquid in an oil well by the method described on page 216 of the 1931 volume or page 150 of the 1933 volume

Defendant's Exhibit Q—(Continued)

and to use the density in performing the computations states on page 194 of the 1931 volume.

Claims 21 to 25, inclusive, and 35 to 38, inclusive, are further rejected as unpatentable over pages 194 and 216 of the 1931 volume and pages 152, 153 of the 1933 volume of Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Division, supra. It would not be invention to determine pressures in a well by finding the density of the liquid by the method stated on page 216 of the 1931 volume and thereafter computing the pressures by the method stated on page 194 of the 1931 volume and thereafter plotting the pressures and productions as illustrated on page 216 of the 1931 volume and pages 152, 153 of the 1933 volume to determine the maximum potential capacity.

Claims 26 to 33, inclusive, are further rejected as unpatentable over page 150 of the 1933 volume or page 216 of the 1931 volume of the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Division, supra. These pages teach how density may be measured by comparing height of a column of oil and the pressures. It would not be invention to determine the pressures and height of the column by depressing the liquid level in the well.

Claims 6, 9 and 18 are further rejected and claim 11, is rejected as unpatentable over pages 353 and 354 of the 1932 volume of Transactions of the American Institute of Mining and Metallurgical Engi-

Defendant's Exhibit Q—(Continued)

neers, Petroleum Division, supra. These pages disclose the measurement of pressure and liquid level. It would not be invention to make a graph using such measurements. It is noted that claim 11 states that the arrival of the liquid surface at the pump is determined by detecting waves produced by the pump. Since it is well known that a liquid pump will create a pressure wave when a portion of gas gets into the pump, it would not be invention to determine the arrival of the liquid level at the pump inlet by detecting pressure waves.

Claims 21 and 24 are specific to the method graphically illustrated in Fig. 6 because each includes the steps of "determining the pressure . . . while the pump is operating at one rate . . ." and "changing the rate . . .". Claims 22 and 23 are specific to the method graphically illustrated in Fig. 5 because each includes the steps of "determining the . . . non-producing pressure . . ." and "determining the pressure . . . when the pump is operating . . .". Claim 25 is specific to the method illustrated in Fig. 6 because it includes the steps of "determining the . . . pressure . . . when the pump is operating at its normal . . . rate . . ." and "reducing the producing rate. . .".

Claim 35 is specific to the method illustrated in Fig. 6 because it includes the steps of "determining the location of the liquid level under one . . . rate of production by said pump . . ." and "changing the rate of production . . .". Claim 36 in specific to the method illustrated in Fig. 6 because it in-

Defendant's Exhibit Q—(Continued)

cludes the steps of "locating the . . . level under one . . . production . . ." and "altering the production rate . . .". Claims 37 and 38 are specific to the method illustrated in Fig. 5 because each includes the step of "locating the level . . . when the pump is idle".

The claims include claims specific to each of more than one species of invention as follows:

I. Claims 21, 24, 25, 35 and 36 are specific to the method illustrated in Fig. 6.

II. Claims 22, 23, 37 and 38 are specific to the method illustrated in Fig. 5.

There being no generic claim, Applicant must restrict his specific claims to one species before further action on the merits will be given. Sub-combination claims 1 to 20 and 26 to 33 may go with either group.

All of the claims, except claims 12 to 17, have been examined in order to expedite the prosecution.

A distinct line of division should be maintained between this application and all copending applications of the same inventor.

A D. McFADYEN,
Examiner.

Defendant's Exhibit Q—(Continued)

Mail Division Jan 3 1939. U. S. Patent Office.
U. S. Patent Office, Jan 4 1939. Division 36.

In the United States Patent Office
Division 36—Room 7892

Cranford P. Walker
Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Filed October 26, 1937
Serial No. 171,170

Los Angeles, California
December 29, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of November 1, 1938, please amend the above identified application as follows:

Page 23, line 23, before the period, insert

(C1)

—(the liquid surface being at the pump inlet, its density may be disregarded in the calculations for production capacity).

Page 25, Line 2, after the period, insert

(C2)

It should also be noted that all of the measurements necessary to provide for the computations and calculations explained herein may be accomplished without interrupting the operation of the

Defendant's Exhibit Q—(Continued)

pump except for the measurement of the static pressure as described herein.

Cancel Claims 1 through 11 and substitute the following:

(C3)

~~39. The method of determining the liquid pressure~~ at any desired level below the surface of the liquid in an oil well having a casing and a mechanical pump suspended therein on tubing and without requiring removal of the pump parts, which consists in the steps of altering the pressure of the gas within the casing to move the liquid surface to the desired level, determining when the liquid surface has reached the desired level, noting the distance between the new level of the liquid surface and the casing head, and noting the casing head pressure of the gas required to so move the liquid surface to the new level whereby the liquid pressure at the desired level is represented by the sum of the noted casing head pressure and the effect in pressure of the column of gas between the liquid surface and the casing head.

—40. The method of determining the liquid pressure at any desired level below the surface of the liquid in an oil well having a casing and a mechanical pump suspended therein on pump tubing and without requiring removal of pump parts, which consists in the steps of maintaining a stable condition of gas pressure in the casing, operating the pump until the liquid level becomes stable, measuring the distance between the casing head and the

Defendant's Exhibit Q—(Continued)

~~surface of the liquid under said stable conditions~~ and while the pump is operating, noting the distance between the surface of the liquid and the desired level, and noting the casing head pressure under said stable condition whereby the pressure at the desired level is represented by the sum of the casing head pressure, the effect in pressure of the column of gas between the liquid surface and the casing head, and the effect in pressure of the weight of the liquid column between the liquid surface and ~~the desired level.~~

1—~~41~~. The method of determining the ~~liquid~~ ~~pres~~ density of the standing column of liquid ∧ ~~sure at any desired level below the surface of the liquid~~ in an oil well having a casing and a mechanical pump suspended therein upon pump tubing and parts without requiring the removal of ~~the~~ pump ∧, which consists in the steps of operating the pump under one stable condition of gas pressure in the casing until the liquid level becomes stable, measuring the distance between the casing head and the surface of the liquid under this stable condition, altering the casing pressure to a new condition, operating the pump at the same rate of production under the new condition of gas pressure to again stabilize the liquid level, measuring the distince between the casing head and the new level of the liquid surface under said new stable condition, and ∧ measuring ~~noting~~ the casing head pressures under the two stable conditions,

Defendant's Exhibit Q—(Continued)

whereby the pressure exerted by the liquid per unit of height of the liquid is represented by comparing the difference in height of the liquid surface levels and the difference between the gas pressures on the liquid surface required to maintain the liquid surface at the two levels.

~~—42. The method of determining the pressure~~ of liquid at the inlet of a mechanical pump suspended in an oil well upon pump tubing and without requiring removal of pump parts, which consists in measuring the distance between the casing head of the well and the pump inlet, building up within the casing a gas pressure sufficient to maintain the liquid surface at or approximately at the level of the pump inlet, determining when the liquid surface is at the pump inlet, and noting the casing head pressure of gas required to maintain the liquid surface at such location, whereby the pressure of the liquid at the pump inlet is represented by the sum of the noted casing head pressure and the effect in pressure of the gas column between the pump inlet and the casing head.—

Cancel Claims 18, 19 and 20 and substitute the following:

C4

—43. The method of determining the static pressure at any point below the liquid surface of a well having a casing and a mechanical pump suspended therein on pump tubing and without requiring the removal of pump parts, which consists ~~in the steps of measuring the distance between the~~

Defendant's Exhibit Q—(Continued)

~~normal liquid level when gas is flowing from the~~ casing head and the pump is not operating, noting the casing head pressure under these conditions, closing the casing and allowing the gas within the well to depress the surface of the liquid to a new stable level, measuring the distance between the new liquid level and the casing head, and noting the casing head pressure required to hold the liquid at the new level, whereby pressure exerted by the liquid per unit of height is represented by comparison of the difference in height of the two liquid levels with the difference in gas pressure exerted upon the liquid surface at the two levels.—

Cancel Claim 21 and substitute the following:

C5

—44. The method of determining the maximum potential capacity of an oil well having a casing and a mechanical pump suspended therein upon tubing and without requiring the removal of pump parts, which consists in the steps of maintaining one condition of gas pressure at the casing head while the pump is operating at one rate of production, measuring the distance between the liquid surface and the casing head under these conditions, changing the rate of production of the pump and while the pump is operating building up the gas pressure at the casing head to depress the liquid surface to a point approximately level with the pump inlet, measuring the distance between the new liquid surface level and the casing head, comparing

Defendant's Exhibit Q—(Continued)

the difference in height of the liquid surface under the two conditions with the difference in gas pressure on the liquid surface required to change the height of the liquid, and then comparing the amount of change in the production rate under the two conditions with the corresponding change in liquid pressures at the pump inlet under the two conditions, whereby the ratio thus found may be used to extrapolate the rate of production for zero or any other pressure at the pump or at other locations below the normal producing level of the liquid in the well:—

Cancel Claim 22 and insert the following:

C6

—45. The method of determining the potential production capacity of an oil well having a casing and a mechanical pump suspended therein on tubing and without requiring the removal of pump parts, which consists in determining the static or non-producing pressure of the liquid at the pump inlet by closing the casing head, allowable the pressure of gas escaping from the fluid to depress the level of the liquid to a stable condition while the pump is idle, measuring the distance between the surface of the liquid and the casing head under this condition, whereby the pressure at the pump inlet is represented by the sum of the casing head pressure, the effect in pressure of the gas column and the effect in pressure of the liquid column between the surface and the pump inlet; then deter-

Defendant's Exhibit Q—(Continued)

mining the pressure at the pump inlet when the pump is operated at a predetermined production rate by allowing the pump to operate at said production rate, measuring the distance between the casing head and the liquid surface when the pump is so operating, whereby the pressure at the pump inlet under this production rate is represented by the sum of the casing head pressure, the effect in pressure of the gas column and the effect in pressure of the column of liquid above the pump inlet, and comparing the difference in the two pressures of the liquid at the pump inlet with the difference between the static and operating production rates to determine the production capacity of the well at zero pressure of liquid at the pump inlet.—

Claims 23 and 24, Line 2, after "well" insert.

C7

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts—.

Claim 25, Line 2, after "well" insert

C8

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts,—.

Claims 26 and 27, Line 2, after "well" insert

C9

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts,—; Line 3, change "well" to read —annular space between the pump tubing and the cas-

Defendant's Exhibit Q—(Continued)

~~ing—; Line 6, after "pressure" insert —on the~~ liquid surface—.

Claims 28, 29 and 30, Line 2, after "well" insert

C10

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts,—; Line 3, change "well" to read —annular space between the pump tubing and the casing—.

Claims 31, and 32, Line 2, after "well" insert

C11

—having a casing and a pump suspended therein and on tubing and without requiring removal of pump parts,—.

Claim 33, Line 2, after "well" insert

C12

having a casing and a pump suspended therein and on tubing and without requiring removal of pump ~~parts,—~~; Line 3, change "well" to read —annular space between the pump tubing and the casing—; Line 9, change "pressure" to —difference between the pressures—.

Claims 35, 36 and 37, Line 2, before "pump" insert —mechanical—; same line, after "therein" insert —and without requiring removal of the pump parts—.

Claim 38, Line 2, before "pump" insert —mechanical—; same line, after "therein" insert —and without requiring removal of the pump parts—; Line 13, after "comparing" insert —the difference between—; Line 14, after "pressures" insert —with the difference in the two fluid levels—.

Defendant's Exhibit Q—(Continued)

REMARKS

In view of the last Office action, this application has been carefully reviewed.

The "Examiner's statement that the pressure gage at the casing head should be shown is noted. However, it is requested that this correction to the drawing be held in abeyance until the allowance of claims in this application.

The Examiner's rejection of the claims in this application on the ground that they do not fall within the statutory classes of invention but merely define methods of computing is believed to be incorrect since the applicant is not attempting to claim the mathematics nor the mathematical computation of the various results but he is claiming those physical steps which are required to obtain the factors necessary to make the calculations.

However, Claims 1 through 11 have been cancelled and new Claims 39 through 42 are presented herewith, each of these claims being drawn to the methods specified which includes the series of physical steps necessary to obtain the factors and then in a "whereby" clause the usefulness or the result which can be obtained by using these factors in computations is stated. It is believed that this form of claim avoids the Examiner's criticism in that the computations stated in the "whereby" clause do not constitute a claiming of the computations as steps in the method but are merely illustrative of

Defendant's Exhibit Q—(Continued)

the manner in which the factors obtained by the physical steps can be successfully utilized to achieve the result sought.

In the same manner Claims 18, 19, 20, 21 and 22 have been cancelled and new Claims 43, 44 and 45 substituted, drawn along the same lines as Claims 39 through 42.

However, the remaining claims in this application have been left in their original form except to make such amendments as inserting features inadvertently left out of these claims on their original draft. Each of these claims does not depend for its patentability upon the computations nor upon the precise mathematics involved but sets forth the physical steps which are required to be performed in order to obtain the information constituting the result of the employment of the applicant's method.

Before discussing the merits of the individual claims in this application, it is believed advisable to call the Examiner's attention to the fact that the applicant herein has presented certain methods of determining pressure of the liquid at any point below the surface thereof, of determining the density of the liquid in a well, and of determining the maximum production capacity of a well, all of which methods relate to and may be applied to wells containing mechanical pumps suspended upon pump tubing as distinguished from "flowing" wells. At the outset the Examiner must keep in mind that the conditions existing in "flowing" wells, that is, wells

Defendant's Exhibit Q—(Continued)

in which the liquid is forced to the ground surface by natural pressures in the formation and in the ground, are entirely different from those encountered in wells which are being mechanically pumped. For example, the pressure at one point below the liquid surface in a "flowing" well varies as the depth of such point below the liquid surface. Again the density of the liquid at any point in a "flowing" well varies as the depth of such point below the liquid surface.

A further condition which must be kept in mind is that in "flowing" wells the flow tubing is free of obstruction so that pressure bombs, pressure recorders and other instruments may be readily inserted into the well and lowered to the liquid surface. In wells which are being mechanically pumped it is impossible to lower any such instruments through the pump tubing without first removing the pump and it is impossible to place any such instruments down through the annular space between the pump tubing and the casing due to the fact that the tubing "corkscrews" down through the casing, leaving no unobstructed channel through which such instruments may pass.

Keeping in mind these facts, it will be apparent that the applicant has attacked an entirely new problem when he provides means and methods for determining the three factors, pressure, density and capacity, in a well being mechanically pumped and that he has provided such means and method as will

Defendant's Exhibit Q—(Continued)

permit determination of these factors without requiring the removal of any of the pump parts and with a minimum of time and effort required.

With regard to the claims directed to the meth- of determining the pressure (original Claims 1 through 11), Claims 1 through 11 have been rewritten as Claims 39 through 42, in which it is definitely stated that the method applies to wells in which mechanical pumps are employed for pumping the well and then follows the steps of the method of determining the pressure at any point below the liquid surface which in Claim 39 includes (a) the step of changing the pressure in the casing to move the level of the liquid to the desired level; (b) determining when the liquid surface has arrived at this level; (c) measuring the casing head pressure required to so locate the liquid level and adding to this pressure the effect of the weight of the gas column. This claim defines the method which has heretofore been uncontemplated and including two new steps, that of depressing the liquid from its normal level to the level at which the measurement is to be made and then determining when the liquid has arrived at this level.

At this point it should be noted that the applicant is not claiming that he has invented merely the step of adding the effect of the weight of the gas column to the casing head pressure since that is merely ordinary physics. The applicant is claiming the manner in which the casing head pressure can be related

Defendant's Exhibit Q—(Continued)

to the pressure of the liquid at any point below the normal liquid level.

The Examiner has referred to the following publications:

(1) Pages 124 and 135 of the 1928-1929 volume of Transactions of the American Institute of Mining and Metallurgical Engineers; and (2) Page 194 of the 1931 volume of the said institute. Both of these publications relate to and apply to only "flowing" wells. The first of these publications requires the lowering of a pressure responsive diaphragm into the well so that a direct reading of the pressure existing at the point at which the diaphragm is located may be made. This is not the method described by the applicant in Claim 39. The only contribution made by this article is the statement on Page 135 to the effect that the pressure for the diaphragm read at the casing head must be corrected for the weight of the gas column between the diaphragm and the casing head. This is not a disclosure of the applicant's method of measuring the pressure but in effect merely states that some pressure is exerted by the weight of the gas column. The applicant, on the other hand, does not lower a pressure responsive diaphragm but instead he merely reads casing head pressure (that is, the pressure in the entire casing as read on a gage merely coupled with the casing head) and he compensates for the gas column by first finding out where the liquid surface is and then calculating the effect in pressure

Defendant's Exhibit Q—(Continued)

of the column of gas between that location and the casing head.

The second of the publications on Page 194 merely states that the pressure at the bottom of the flow tubing may be calculated by adding to the casing head pressure the effect due to the weight of the gas column. This presupposes that the liquid surface is at the bottom of the flow tubing but, if it is not, gas may be introduced in the annular space about the flow tubing to insure that it is free of liquid. This article does not disclose how the pressure at any point below the liquid surface may be measured but merely discloses how liquid can be forced down to the level of the bottom of the flow tubing. As a matter of fact, unless the liquid is at the bottom of the flow tubing in a "flowing" well, any calculation of pressure as disclosed in this article would be entirely erroneous.

New Claim 40 is directed to the determination of the liquid pressure at any level below the surface including the steps of, first, operating the pump until the liquid level becomes stable, second, determining the location of the level under these conditions, third, adding to the casing head pressure the weight of the column of gas determined by measurement of the liquid level, and then adding the effect in pressure of the weight of the liquid column between the known surface of the liquid and the level or point at which the pressure calculation is desired.

Defendant's Exhibit Q—(Continued)

This claim defines steps not contemplated in any of the articles, particularly the step of determining where the liquid surface lies, to find the extent of the gas column and to permit determination as to how far below this surface the desired point lies at which the pressure measurement is to be made. None of the references contemplate any such steps and are totally lacking in any teaching which would result in this information.

Claim 41 introduces the still further steps of changing the gas pressure from one pressure to another to change the level of the liquid and to use the information as to the two liquid levels and the pressure required to create such change in the level as the means for determining the pressure at the desired point below the liquid surface. A most careful reading of both of the publications cited against this claim, as well as the remaining publications cited by the Examiner, fails to disclose any such steps other than merely that in order to obtain the pressure existing on the surface of the liquid it is necessary to add the weight of the gas column provided the length of such gas column is known but which none of the authors supply means or method for determining.

New Claim 42 introduces the additional step that the pump must operate at the same production rate under the new condition of gas pressure which is a still further condition not contemplated by any of the references.

Defendant's Exhibit Q—(Continued)

New Claim 43 defines the method by which the pressure at the inlet of a mechanical pump may be determined which includes the step of first moving the liquid surface to the pump inlet, maintaining the liquid surface at the pump inlet, and using the measurement of the gas pressure required to perform these steps as the means for determining the desired pressure. None of the references disclose this important means and method of calculating the pressure.

In new Claim 43 the applicant defines that series of steps which he has devised which will permit a measurement or calculation of the static pressure at any point below the liquid surface of a well, this claim defining the same subject matter as Claims 19 and 20 but setting forth the steps of first measuring the normal liquid level when the pump is not operating and the pressure at the casing head under these conditions, then closing the casing head and depressing the surface of the liquid to a new stable level, noting the casing head pressure to maintain the liquid at the new level, and then utilizing the difference in pressure and the difference in height of the fluid to calculate the desired information. These are physical steps not contemplated in any of the references and in the present form it is believed that Claim 43 is allowable.

The applicant has therefore provided the oil industry with a new novel and simple means for obtaining pressure information from a well containing a mechanical pump, this information being sub-

Defendant's Exhibit Q—(Continued)

stantially impossible to obtain before the applicant's invention. The use of pressure bombs or other pressure recording devices in wells of this character would only permit the measurement of the pressure at whatever level the pump might be located but did not provide a means for calculating the pressure at other points in the liquid. The applicant has therefore contributed an important and valuable advance in the oil art and it is believed that he is entitled to the full protection set forth in new Claims 39 through 43.

With regard to claims directed to the feature of determining the maximum potential capacity of the well, new Claims 44 and 45 constitute old Claims 21 and 22 rewritten in somewhat the same form as has been adopted for Claims 39 through 43, namely, setting forth the physical steps of the method invented by the applicant and summing up how the information obtained by these physical steps can be correlated and used to obtain the information desired.

In the rewriting of these claims care has been taken to avoid the objectionable features pointed out by the Examiner on Page 5 of the last Office action, while the specification has been amended to avoid the objectionable features pointed out on Page 3 of the last Office action.

As to the criticism in the first paragraph on Page 6, the Examiner's attention is called to the fact that with the information obtained by the physical steps recited in Claims 44 and 45 a ratio is determined

Defendant's Exhibit Q—(Continued)

which can then be used to compute the rate of production not only when the pump operates in its then location to reduce the pressure to zero at the pump inlet but the production may also be computed for some other new or possible location of the pump whereupon the operator of the well may determine that while his maximum production rate with the present location of the pump is a certain value, the well is capable of producing more oil should he lower the pump or raise the pump in order to obtain a better gas separation and hence a better volumetric efficiency from the pump. All of this is explained carefully in the specification and the expression "at other locations" is employed for the very purpose of preventing interpretation of these claims to mean that the results of the method will apply only to the then location of the pump.

In view of the fact that the references applied by the Examiner to Claims 21 through 25 are Pages 194 and 216 of the 1931 publication and Pages 152 and 153 of the 1933 publication, the Examiner's attention is called to the fact that again these publications refer only to "flowing" wells. Page 216 of the 1931 publication merely refers to a method of determining the density of the fluid in the "flowing" well between the lower end of the flow tubing and the point in the well at which the fluid is "likely" to be entering the well bore. The Examiner must remember that the density in a "flowing" well differs from the density of the annular space of a well

Defendant's Exhibit Q—(Continued)

being pumped in that the density increases from the lower end of the tubing to the point at which the fluid enters the well bore. This publication does not describe a method which can be applied to pumping wells nor does it disclose any information which added to the information contained in the 1933 publication to achieve the result obtained by the applicant.

However, it should be noted that new Claims 44 and 45 define the applicant's method as applied and limited to wells which contain a pump suspended upon tubing to further distinguish these claims from the "flowing" well methods. In the same manner Claims 23, 24 and 25 have been amended to limit them to wells containing pumps to distinguish these claims from "flowing" well methods such as those disclosed.

Pages 152 and 153 disclose only the steps of taking the static and the flowing pressures with a pressure bomb but do not include the steps which the applicant employs of utilizing the location of the liquid level at different points within the casing at different pressures within the casing for the purpose of determining and calculating the production capacity.

Claims 26 through 33, which are directed to the applicant's method of determining density in a well which contains a pump by employing the steps of changing the liquid level in the well and comparing the change in liquid level with the change in gas

Defendant's Exhibit Q—(Continued)

pressure required or resulting from the change in level, are not met by the disclosures contained in the pages of the 1933 publication. Page 150 of this publication merely described a method of calculating the static bottom hole pressure in artesian type wells by using a pressure bomb and thus to determine the density in the well and from this density he computes the pressure due to the fluid column. Why he does not take the static bottom hole pressure direct with the bomb is an unexplained mystery. However, regardless of the mystery, he does not disclose the use of the two levels and the difference in pressure necessary to maintain the liquid at these two levels as the means for determining the density of the fluid.

Again Page 216 of the 1931 volume does not disclose any method for obtaining the density under thhe conditions set forth by the applicant which employs using the two levels of liquid and the pressure necessary to maintain these levels.

The Examiner has rejected Claims 26 through 33 as covering the obvious way of measuring density. The applicant cannot agree with this rejection since prior to the introduction of this method into the industry by the applicant no one measured density by this method. As a matter of fact, no one knew how to determine the density of the liquid in a well which was being pumped and the oil industry has welcomed the applicant's method as being a simple and economical way in which to acquire information impossible to achieve before.

Defendant's Exhibit Q—(Continued)

The Examiner has rejected Claims 26 through 33 as unpatentable over Hay, Stancliffe or Field. Each of these references discloses a means for determining the density or specific gravity of a liquid in a tank which consists in positively inserting into the liquid at two different levels pressure measuring devices and then by computing from the information obtained the density of the liquid. The applicant is not claiming that he is the first to determine that the specific gravity of a liquid can be determined by taking pressure measurements at two different levels but he is claiming that he is the first to conceive and disclose the method of taking density measurements in an oil well having a pump which prevents the insertion of pressure measuring devices and he is claiming that he is the first to conceive and disclose that method which includes the changing of the liquid level by gas pressure and utilizing the information so obtained for the purpose of density computations. What the Examiner says is true; it would not amount to invention to divide the difference in the pressures at two locations by the distance between those locations but it does require invention to find out how to measure that pressure at the two locations for density measurements by using the steps set forth in the claims. If it were possible to readily take those measurements of pressure, the Examiner might have some argument but up to the present time no one other than the applicant has found an adequate method

Defendant's Exhibit Q—(Continued)

of measuring the density of the liquid in an oil well having a pump and he is therefore entitled to full protection upon his advance in this art.

The specification has been amended to more clearly bring out the fact that the density determination may be determined while the pump is being operated by the insertion made on Page 25 at Line 2. It was believed, however, that the original specification made it obvious that all of the measurements referred to in the specification, with the exception of the static pressure measurement, were to be accomplished while the pump was running since the primary object of all of the methods disclosed herein is to permit the various measurements to be taken without requiring removal of the pump parts and without requiring interruption in the production from the well.

Claim 33 has been corrected to avoid the rejection of incompleteness by stating in the next to the last line that the comparison is made with the "difference" between the pressures.

The Examiner has rejected Claims 35 through 38 as involving new matter. Such rejection is believed to be incorrect. On Page 19 of the original specification it was stated how by using the pump to change the liquid level the production capacity of the well could be calculated, the pressures referred to on that page being the pressures at the pump inlet which is "a known location" and includes not only the pressure of the gas upon the surface of the liquid but also the computation of the pressure exerted by

Defendant's Exhibit Q—(Continued)

the weight of the liquid column above the pump inlet. Again on Page 20 it is stated that by changing the production rate of the pump and comparing the fluid pressure at the pump inlet under the two conditions of production the production capacity of the well may be determined. It follows therefore that, as explained on Pages 19 and 20, by utilizing two pressures at the pump inlet and comparing the difference in these pressures with the difference in the liquid levels in the well under the two pressure conditions, the production rate may be calculated. In wells having substantially no gas pressure the computation of the pressure at the pump inlet consists merely in determining where the fluid level is and computing the effect in pressure of the column of liquid above the pump inlet. This represents pressure at the pump inlet. Again when the liquid level has been changed, still under the condition of little or no gas pressure, the pressure at the pump inlet is computed by computing the pressure value of the liquid column now above the pump inlet.

The applicant has disclosed the method of determining the production capacity by comparing two pressures at the pump inlet with two conditions of liquid surface level and he is entitled to a claim covering this, whether the computation of the pressure includes a zero gas pressure or some gas pressure above zero.

Further, on Pages 17 and 18 is clearly disclosed

Defendant's Exhibit Q—(Continued)

the manner in which the applicant may utilize the information acquired by the method set forth in Claims 35 through 38 to determine the rate of production for zero pressure or any other pressure between zero and the actual pressure at the pump inlet, zero pressure at the pump inlet representing operation of the pump at such rate as will draw the liquid out of the well as fast as it flows in.

It is believed that those portions of the specification hereinabove referred to clearly disclose (a) the manner in which the capacity of a well may be determined by comparison of the pressures due to the liquid columns where gas pressure is zero; (b) the manner in which the capacity of the well can be determined by merely comparing the two liquid levels when the gas pressure is zero; (c) the manner in which the rate of production for any pressure between zero and actual pump inlet pressure with the pump in its then location and rate of production.

The rejection of Claim 38 on the ground of involving new matter is believed to be unwarranted in view of the fact that on Pages 16 and 17 of the specification is disclosed a method of determining the pressure at the pump inlet and from that calculating the pressure at any other level. Other portions of the specification as referred to herein describe the manner in which utilization of the pressures so obtained can be employed for the purpose of calculating the production capacity. Whether these pressures are calculated for the pump inlet or for some other known or fixed location below the

Defendant's Exhibit Q—(Continued)

surface of the liquid is immaterial so long as the applicant has disclosed the manner in which such computations of pressures at the other locations can be determined.

The Examiner has rejected Claims 36 and 37 as unpatentable over Lehr of record. The applicant fails entirely to understand this rejection since the applicant is not claiming merely the use of the Lehr device to determine the rates of the liquid levels under two rates of production but has disclosed a complete method for determining production capacity not contemplated and not taught in the Lehr patent and which as one of its steps involves the location of the liquid level. If the Examiner repeats this rejection, further explanation is requested.

The Examiner's classification of Claims in groups I and II is noted. The applicant cannot understand, however, how the Examiner allocates the various claims to these two groups. This entire group, Claims 21 through 25 and 35 through 38, are directed to the method of determining the maximum production capacity of the well which includes comparing two pressures at the pump inlet under two operating conditions of production from the well as, for example, comparing the static or non-producing pressure with the pressure at a normal production rate while others of the claims specify two producing rates, normal and a "reduced" rate.

Claim 24 is believed to be generic in that it specifies the comparison of the pressure at "one rate of production" with the pressure at the pump inlet

Defendant's Exhibit Q—(Continued)

for a "changed" rate of production. This will read upon both Figs. 5 and 6 since "zero production rate" gives and must be considered as "a production rate". It is therefore believed that the applicant has presented generic claims and is therefore entitled to specific claims to two species or two forms of the method disclosed. Reconsideration of the requirement that the applicant restrict specific claims to only one species is therefore requested.

In making the foregoing amendment a sincere effort has been made to meet each of the Examiner's rejections and objections in order to expedite the prosecution of this application and it is believed that upon reconsideration of this application all of the claims will be found to be allowable.

Respectfully submitted,

HAROLD W. MATTINGLY
Attorney for Applicant

HWM:MM

Defendant's Exhibit Q—(Continued)

12

February 8, 1939

In re application of:
Cranford P. Walker
Ser. No. 171,170
Filed Oct. 26, 1937
For: Method of Determining Fulid Density, Fluid Pressure and the Production Capacity of Oil Wells

Examiner, Division 36:

Division has been required under Rule 41 between:

I. Claims 24, 25, 35, 36, 44 and
II. Claims 23, 37, 38, 45.

There appear to be no generic claims, the remaining claims in the case, 26-33 and 39-43, being subgeneric, and claims 12-17 being retained under Rule 42.

The groups cover mutually exclusive species and division is approved, pending the non-allowance of a generic claim.

Respectfully,

MARK L. WHITNEY
Examiner of Classification

BEL
BEL:af

Defendant's Exhibit Q—(Continued)
Mail Division Feb. 11 1939 U. S. Patent Office.
In the United States Patent Office

Cranford P. Walker

Method of Determining Fluid
Density, Fluid Pressure, and
the Production Capacity of
Oil Wells

Filed October 26, 1937
Serial No. 171,170

PETITION TO MAKE APPLICATION SPECIAL

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Now comes your petitioner, by his attorney of record, and requests that this application be made special for examination, and that the Examiner in charge thereof be instructed to take this application up for action out of its regular turn.

Your petitioner avers that he is engaged in the business of making surveys of oil wells, particularly wells containing mechanical pumps for pumping the oil to the ground surface, this business consisting essentially in obtaining information as to the pressure existing in the liquid in the well at any desired point below the surface of the liquid, the determination of the density of the oils in any particular well under measurement and in the determination of the maximum possible production capacity (known as

Defendant's Exhibit Q—(Continued)

potential) of the well, all of which information is obtained by applicant without the necessity of interruptnig normal production from the well and without the necessity of removing the pump, pump tubing, or any of the mechanical pump parts.

That applicant's method as set forth in the above entitled application and as claimed therein has met with instant commercial success and is now adopted for standard practice by the major oil companies of the United States, and was welcomed by the oil industry in solving a problem that has vexed the industry until applicant's solution therefor was presented.

Your petitioner avers further that, prior to his introduction into this field of his method and apparatus as described and claimed in this application, there was no other similar method and process known in this field and that, subsequent to his introduction of this method and process, a competitor inspected and studied applicant's process and thereafter entered competition with your petitioner employing oil well survey devices including means for producing pressure waves in the oil wells, mechanism for recording the echoes from the obstructions in the well, mechanism for tuning or accenting the echoes from the tubing collars, and the competitor is practicing the methods and processes for obtaining liquid pressures, densities and production capacity of the wells by steps of measuring liquid levels, depressing the liquid surfaces by the employment of different pressures of gases and by employing dif-

Defendant's Exhibit Q—(Continued)

ferent rates of production from the well in the manner described and claimed in this application.

That the manner in which the competitor is conducting the competing business is such that not only applicant but the public are subject to great damage and injury and possible loss of the benefits of applicant's invention which can be saved if the business can be conducted and controlled by proper patent protection and controlled licensing.

That the petitioner further avers that until the patent is granted he is helpless to prevent this destructive competition.

That your petitioner further avers that he has actively and diligently prosecuted this application by promptly amending the application as soon as copies of the cited publication could be obtained, and further attempted to have this application considered in a personal interview for the purpose of expediting the early issue of the patent.

Your petitioner further avers that both he and his attorney of record have diligently searched the prior art and in the opinion of his attorney of record each and every of the claims now presented in this application is patentable.

That, in the opinion of his attorney, the competitor is infringing all of the claims now presented in this application.

That attached hereto are affidavits verifying the statements made in this petition, including an affidavit by your petitioner Cranford P. Walker, an

Defendant's Exhibit Q—(Continued)

affidavit by his attorney of record, Harold W. Mattingly, an affidavit by Ernest K. Parks, a petroleum engineer, an affidavit by Walton E. Gilbert, equipment engineer of the Shell Oil Co., an affidavit by Elwin B. Hall of the Hall-Baker Co., and an affidavit of R. L. Keyes of The Texas Company (Calif.)

Respectfully submitted,

CRANFORD P. WALKER

By HAROLD W. MATTINGLY

His Attorney.

Washington, D. C.,
February 11, 1939.

Mail Division Feb 11 1939 U. S. Patent Office.

In the United States Patent Office

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Filed October 26, 1937
Serial No. 171,170

AFFIDAVIT OF CRANFORD P. WALKER

Cranford P. Walker, being duly sworn, deposes and says that he is the inventor named in the above-entitled application for United States Letters Patent.

That he is actively engaged in the business of making oil well surveys to determine the pressures

Defendant's Exhibit Q—(Continued)

below the oil surface, the densities of the oil in wells and the maximum production capacity of oil wells.

That as soon as he introduced his method of obtaining this information as set forth and claimed in the above-entitled application, the same was welcomed by the oil industry and has met with great commercial success as evidenced by the attached list, marked Exhibit B, of companies that have employed him to make these surveys on their wells.

That, prior to his introduction to the oil industry of the methods described and claimed in this application, applicant's methods and processes were not known to the oil industry as is verified in the attached affidavits of Ernest K. Parks, Walton E. Gilbert, Elwin B. Hall and R. L. Keyes.

That, after applicant introduced to the oil industry the methods described and claimed in this application, representatives of a competitor, International Geophysics Inc., then not engaged in a similar line of activity, came to oil wells on which applicant was practicing his methods and inspected the same and made photographs of applicant's apparatus and, subsequent thereto, the competitor, International Geophysics Inc., entered into direct competition with applicant employing apparatus including sonic echo instruments similar to applicant's for obtaining fluid level measurements in the well and employing method and process steps for obtaining liquid pressure, density and maximum production capacity measurements identical with the methods and processes described and claimed in this application.

Defendant's Exhibit Q—(Continued)

That applicant has personally watched the competitor's tests of oil wells and, from the activities he observed, the charts he has inspected and information furnished to him, he believes that the methods and processes employed by the competitor constitutes an infringement of each and every of the claims now presented in this application.

That the competitor, International Geophysics Inc., is competing with applicant in such manner as to constitute unfair competition with applicant, and the competitor has seriously injured applicant's business and threatens to continue such injury in a manner which may result in the destruction of applicant's business.

That until the said application matures into a patent, he is helpless to prevent said competition and and damage to his business.

That he has carefully inspected the article published in the Petroleum World of February, 1938, constituting Exhibit A, attached to the accompanying affidavit of Harold W. Mattingly and made a part hereof, and that the methods described as practiced by the competitor in that article constitute in his opinion and in the opinion of his legal counsel, an infringement of each and every of the claims now presented in the said application.

That he has personally inspected the apparatus and methods practiced by the said competitor and in his opinion the methods actually practiced by the competitor constitute an infringement of each and

Defendant's Exhibit Q—(Continued)

every of the claims now presented in this application.

That he has caused to be made a thorough search of the prior art, both as to patents and publications, and that in his opinion and in the opinion of his legal counsel, each and every of the claims of the said application are patentable to him.

CRANFORD P. WALKER

Sworn to and subscribed before me this 11th day of February, 1939.

FREDERICK A. ALLMETT
Notary Public.

WELLS TESTED BY DEPTHOGRAPH UNIT

Company	Total No. of Wells	First Well Tested Date
Abrams & Associates	1	May 29, 1937
Ajo Oil Company	1	Sept. 2, 1938
W. P. Andrews Oil Co.	2	Oct. 25, 1938
Apex Petroleum Corp.	3	Nov. 4, 1937
Arrowhead Oil Co.	5	July 3, 1937
Associated Oil Co.	2	Feb. 19, 1937
Axis Petroleum Co.	2	Jan. 20, 1939
Bachmann Petroleum Co.	1	[illegible] 18, 1937
Bankline Oil Co.	10	Oct. 14, 1936
Barnsdall Oil Co.	10	Nov. 11, 1936
Alphonso E. Bell	5	Dec. 1, 1936
Beloil Corp.	1	June 26, 1936
Bolsa Chica Oil Corp.	1	Feb. 15, 1938
Boswell Petroleum Co.	1	June 24, 1938
Calridge Oil Co.	2	Oct. 11, 1938
Chanslor-Canfield & Midway Oil	22	Feb. 18, 1937
Cities Service Co. (Hobbs, N. M.)	1	Dec. 15, 1938
Continental Oil Co.	12	Nov. 27, 1936

Defendant's Exhibit Q—(Continued)

Company	Total No. of Wells	First Well Tested Date
Continental Oil Co. (Hobbs, N. M.)	10	Dec. 16, 1938
Colorado Oil Co.	7	June 25, 1937
Crude Oil Drilling Co.	1	Aug. 1, 1938
Davis Investment Co.	2	April 27, 1936
Dearborn Oil Co.	1	July 12, 1937
Dougan Drilling Co.	1	Aug. 25, 1938
O. C. Field Gasoline Corp.	24	Jan. 24, 1938
G & B Oil Co.	1	Sept. 3, 1938
Gibson Oil Co.	6	Mar. 18, 1937
Graham-Loftus Oil Co.	1	Aug. 6, 1938
Greathouse Oil Co.	1	Aug. 25, 1938
Gypsy Oil Co.	1	July 19, 1938
General Petroleum Corp.	2	June 22, 1937
Hammil Oil Corp.	1	Oct. 1, 1938
Hancock Oil Co.	3	April 13, 1937
Hampshire Oil Co.	1	Aug. 2, 1938
Hathaway Co.	4	June 8, 1938
Hilldon Oil Co.	13	April 5, 1937
Hogan Petroleum Co.	9	June 23, 1938
Honolulu Oil Co.	11	Sept. 1, 1936
Iris Oil Co.	1	Oct. 13, 1938
J. E. F. Oil Co.	1	July 5, 1938
A. S. Johnston Drilling Corp.	8	Feb. 1, 1938
Kobe Inc.	2	April 14, 1938
Kettleman North Dome Assn.	4	May 23, 1938
Lido Petroleum Co.	1	May 27, 1938
Like Petroleumn Corp.	1	June 10, 1938
Lubrite Oil Co.	1	Mar. 24, 1938
A. N. Macrate Co.	1	April 21, 1938
MacDonald & Burns	5	Aug. 23, 1938
MacMillan Petroleum Corp.	3	Mar. 19, 1938
Morton & Elder Oil Co.	2	Feb. 21, 1938
Moyle Petroleum Co.	1	May 6, 1938
McVicar-Rood Co.	4	Sept. 27, 1937

Defendant's Exhibit Q—(Continued)

Company	Total No. of Wells	First Well Tested Date
North American Oil Consolidated	3	May 4, 1937
O'Donnell Oil Co.	3	Aug. 31, 1937
The Ohio Oil Co.	3	Mar. 18, 1938
Oil Incorporated	1	Feb. 3, 1937
Orco Oil Co.	1	May 11, 1938
Otis Hoyt	2	Feb. 17, 1937
Olympic Refining Co.	3	Oct. 14, 1937
Pacific Western Oil Corp.	40	April 23, 1936
J. Perl Oil Co.	1	Nov. 15, 1938
Pima Oil Co.	1	April 2, 1938
The Petroleum Co.	1	April 14, 1938
Petroleum Securities	1	Jan. 25, 1937
Petrol Corp.	38	Nov. 11, 1937
Phillips Petroleum Co.	1	Dec. 8, 1938
Republic Petroleum Co., Ltd.	5	May 10, 1938
Richfield Oil Corp.	13	Oct. 1, 1937
Rio Grande Oil Co.	4	Mar. 6, 1937
Royalty Service Corp., Ltd.	2	April 11, 1938
Shell Oil Co.	94	April 29, 1936
Signal Oil & Gas Co.	2	Aug. 12, 1937
St. Helens Petroleum Co.	4	April 9, 1938
Selbar Oil Co.	1	Feb. 7, 1938
Sheldon Oil Co.	2	June 10, 1938
Signal Petroleum Co.	1	Sept. 14, 1938
Thomas W. Simmons	3	Jan. 3, 1938
Sonwell Oil Co.	1	Sept. 27, 1938
South Basin Oil Co.	10	Aug. 19, 1937
Southern Calif. Drilling Co.	2	Oct. 11, 1936
Sovereign Oil Co.	1	May 21, 1936
Speik Petroleum Co.	1	May 27, 1938
Standard Oil Co. of Calif.	133	May 25, 1936
Sunset Oil Co.	16	Nov. 4, 1937
Sunshine Oil Co.	1	Feb. 12, 1938
Superior Oil Co.	1	Nov. 28, 1938
Termo Co.	6	May 11, 1938
The Texas Co.	37	Aug. 1, 1936

Defendant's Exhibit Q—(Continued)

Company	Total No. of Wells	First Well Tested Date
Union Pacific Railroad Co.	34	Sept. 23, 1937
Utah Oil & Drilling	1	June 24, 1938
Union Oil Co. of Calif.	123	May 8, 1936
Vesta Petroleum Co.	1	Sept. 23, 1938
Weber Butler Oil Co.	1	July 14, 1937
Western Gulf Oil Co.	5	Oct. 13, 1936
Western States Drilling Co.	1	Nov. 3, 1938
Wilshire Oil Co.	5	April 20, 1936
Woolner Oil Co.	4	June 13, 1938
C. F. Yunker	1	April 7, 1938
Zenith Oil Co.	1	July 19, 1938

Mail Division Feb 11 1939 U. S. Patent Office.

In the United States Patent Office

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Filed October 26, 1937
Serial No. 171,170.

AFFIDAVIT OF HAROLD W. MATTINGLY

Harold W. Mattingly, being duly sworn, deposes and says that he is the attorney of record in the matter of the above-entitled application, filed by Cranford P. Walker, Serial No. 171,170, on October 26, 1937, for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Defendant's Exhibit Q—(Continued)

That, upon information and evidence furnished to affiant including an article published in Petroleum World of February, 1938, pp. 59-62, constituting an advertisement of the International Geophysics Inc., (copy of which is attached hereto and made a part hereof and marked "Exhibit A"), a competitor of the inventor, Cranford P. Walker, and including the affidavits of Ernest K. Parks, Walton E. Gilbert, Elwin B. Hall and R. L. Keyes, and information furnished by the inventor, Cranford P. Walker, affiant is informed and believes that, prior to the introduction into the oil fields by applicant of the methods and processes set forth in this application, the same was not known and that the competitor, International Geophysics Inc., after seeing and inspecting applicant's apparatus and methods, later produced apparatus and practiced methods as follows: mechanism for producing pressure waves in oil wells and for recording the echoes from different obstructions in the wells to determine the location of the liquid surface in the well and for accenting the echoes from certain of the obstructions, depressing or changing location of the liquid level in the well, and changing the rates of production from the wells to determine the pressures in the liquid, the density of the liquid and the maximum production capacity of the wells, and that, in affiant's opinion, these methods and this apparatus constitutes an infringement of each and every of the claims contained in this application.

Defendant's Exhibit Q—(Continued)

That he has caused to be made a thorough search of the prior art, both as to patents and as to publications, and, in his opinion, each and every of the claims now pending in the application is patentable to applicant.

HAROLD W. MATTINGLY

Sworn to and subscribed before me this 11th day of February, 1939.

FREDERICK A. ALLMETT
Notary Public.

1260

Figure 1. How instrument for measuring fluid level is connected to the casinghead

Determining Pumping Well Performance

By J. J. Jakosky*

FLUID LEVEL and bottom-hole pressure measurements are proving to be of great value in meeting the demand for more efficient oil recovery and in eliminating wasteful and inefficient pumping practices.[1] This paper reviews briefly the principles of oil recovery in pumping wells, and describes various applications of fluid-level measurements to production problems.

Since the flow of oil from the producing formation into the well is roughly proportional to the pressure difference, oil production is possible only when the pressure in the formation is higher than the pressure in the hole. This higher pressure in the formation forces the oil into the well and production will stop when the pressure in the well at the formation depth becomes equal to the formation pressure. The pressure at the bottom of the well is dependent largely upon the height of fluid. The maximum oil production under ordinary conditions is obtained when the lowest possible fluid level can be maintained. This makes the operating fluid level, therefore, of great importance. The accurate determination of the operating fluid level in a pumping well can be obtained in general by use of two different methods: (a) recording bottom-hole pressure gauges or (b) fluid level measurements.

Bottom Hole Pressure Gauges

The bottom-hole pressure gauge is fastened below the pump, and thereby records the total pressure existing at that depth. These recording gauges have two essential parts: a pressure element open at the bottom end to the pressure to be recorded and a clock-driven chart drum or carriage. A stylus attached to the free end of the pressure element records its movements on sensitized paper or metal sheets affixed to the chart drum or carriage. This whole mechanism is enclosed by a suitable case. At the conclusion of a run the chart record is recovered when the instrument is pulled from the well. Pressures at various times of the test are determined by comparing the recorded pressure stylus movement with pressure calibration curves of the instrument.

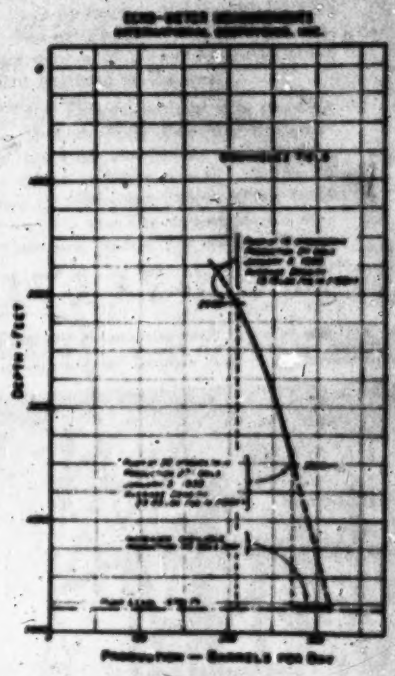
To obtain bottom-hole measurements with instruments of this type it is necessary to pull the rods and at times even the tubing in order to lower the instrument to the well bottom, where the readings are made over the desired period of time. The recording must be made over a sufficient period of time to insure that equilibrium conditions have been reached after the shut-down period preceding installation of the bottom-hole gauge. After completion of the recording, the rods (or rods and tubing) are again pulled in order to recover the instrument with its data. The recorded data are then available for analysis and proper guidance of the subsequent pumping operations. The cost or rental charge for the instrument, the loss of oil production during the two periods the well is shut down when installing and recovering the gauge, and the cost and hazard of the two pulling jobs, are all directly chargeable to the cost of obtaining these data.

Instruments for Measuring Fluid Level

The second method (as exemplified by the Echo-Meter) measures the operating fluid level while the well is pumping, and without pulling either rods or tubing. These measurements can be made at different rates of production or at different casinghead pressures, and the bottom-hole pressure calculated. / As most wells are equipped with a gate valve, plug cock or a bull plug in the casinghead, it is a comparatively simple job to connect the Echo-Meter instrument to the casinghead, as shown in Fig. 1. The component parts of the Echo-Meter are a highly sensitive microphone, a special cartridge to initiate a very sharp-fronted sound wave, vacuum tube amplifier and recording camera, the necessary valves and a gauge to show the gas pressure in the casinghead. The instrument is connected to the recording truck by a shielded cable.

When the cartridge is fired, a sharp-fronted sound wave is sent into the casinghead. This sound wave travels down the annular space between the tubing and casing at a speed which varies with the gas composition. Under California conditions the speed may vary from 850 to 1400 feet per second in different wells. The speed has been found to be practically constant throughout the entire length of any one well. As the sound wave travels down the well it is gradually absorbed and partially reflected by any obstructions encountered. Small collections are generated by tubing collars and travel back up the casing to the instrument. Tubing anchors and liner tops send back much stronger reflections. The fluid oil surface reflects practically the whole wave front which has traveled to the bottom of the well. When these reflections return to the instrument, they are picked up by a special microphone which generates a variable but minute electric current that is conducted by the cable to the recording truck. Here the small current is

*Method and Apparatus patents pending.



*Chief Director, International Geophysics, Inc., Los Angeles.

[1] Lloyd Herald, "Present Status of Bottom Hole Pressure Work," California Oil World, Aug. 25, 1934. [2] D. L. Katz and W. H. Barlow, "Relation of Bottom Hole Pressure to Production Control," API Drilling and Production Practice, 1935. [3] H. A. Berg, "Bottom Hole Pressure Bomb Adapted to Equipment for Wells," Oil and Gas Journal, October 12, 1933.

171170 2

Exhibit A.

104R

THE Electrical

ECHO-METER

for accurate fluid level determinations

Fluid Level Determinations furnished by *ECHO-METER*† are of great value in *decreasing the cost of pumping* and in observing the *producing characteristics* of the well. The accuracy and rapidity of *ECHO-METER* measurements plus the low cost of this service account for the ever-increasing use of Fluid Determinations. All of this information is obtained without excessive pumping speeds or dangerous production rates which usually are harmful to the well.

From *ECHO-METER* Determinations it is possible to accurately compile Bottom Hole Pressure information which shows the operating conditions in the well—determine Potentials which indicate a well's ability to produce—compute the Productivity Index which indicates changes in production and the causes therefor—obtain the Proper Pumping Speed for most efficient oil recovery, etc.

† Trademark

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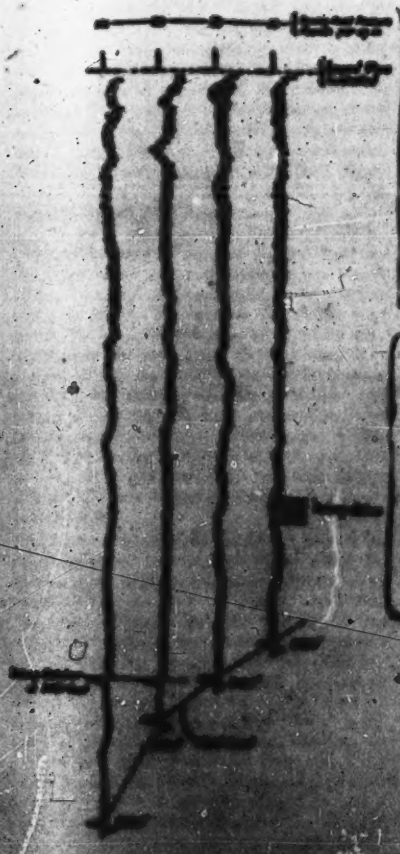
IGI



for a second measurement after equilibrium conditions had been established. On January 4, 1938, another [illegible] fluid level measurement was made. The level was then found to be at 3000 feet, or 2000 feet above the pump, and the well was producing 211 barrels per day. These data are plotted in Fig. 2. By extrapolating the values it is indicated that there is available a gross production of about 316 barrels per day, which is 45 barrels per day more than previously had been assumed. This available increase in production is obtainable by increasing the pump displacement, either by speeding it up or by replacement with a larger-sized pump.

Determining Fluid Density and Bottom-Hole Pressure

The [illegible] process is of considerable importance in determining the operating conditions in a well. One convenient way to determine the static bottom-hole pressure of the casing is to measure the changes in fluid level at different pump pressures. This may be done by building up the casinghead pressure by opening the gas through a high-pressure regulator and measuring the resulting increased fluid levels in the well at different gas pressures. The bottom-hole pressure at the pump equals the weight of the fluid column down to the pump + (the weight of the gas column) + (the casinghead pressure). This may be illustrated by the following data:

In Fig. 3 are shown four separate fluid level measurements made on a well in the Los Angeles Basin. Reading right to left, the measurements are first, second, third and fourth. Considering them in order: The first was recorded with a casinghead pressure of 20 lbs./square inch and the fluid level was found to be at 3700 feet. The second recording, made after equilibrium had again been reached, was with a pressure of 30 lbs./square inch with the fluid level at 3185 feet. The third record shows that with 40 lbs./square inch the fluid level was found down below the tubing socket (which is at a known depth of 3301 feet) to a level of 3404 feet. The fourth recording was made at 45 lbs./square inch with the fluid level measured at 3777 feet. Throughout this series of measurements the well's production was an unvaried amount.

The fluid level is measured in equilibrium with the real pressure existing down in the pump; pressure is equal to the weight of the gas column plus the casinghead pressure. The weight of the gas column by distance is determined by the specific gravity of the gas and by the temperature of the column. The weight of the fluid column down to the pump equals the bottom-hole pressure minus the weight of the gas column.

Echo-Meter Measurements

Petroleum Engineering
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INTRODUCING
the Electrical
ECHO-METER
for accurate fluid level determinations

Location of the fluid level in a pumping well is of vital importance for get maximum production and greatest pumping efficiency. It is necessary to maintain the proper fluid level. Whenever changes take place which interfere with a low fluid level, there's the oil down to efficient wells, a Echo-Meter, an accurate, up-to-the-minute fluid level measurement can save the hundreds of dollars and of a small part without shutting down the pump, pulling the rods or tubing or breaking the well pressure. In one easy operation of the Echo-Meter the fluid level is obtained, by recording on a film the time required for a sharp shock wave to travel from the pulling head to the fluid and return. In addition to the distance from the fluid level, other conditions are disclosed, how pulling units, tubing strainers, flow lines, etc., providing a wide field of service.

[illegible]

[illegible]

as fluid level at equilibrium conditions. Due to changes in solubility of gas in oil and also the change in volume of the gas with a change in pressure, the fluid density varies from a maximum value at the bottom of the column, to a minimum value at the top of the column. By analyzing the first fluid level determination, it will be seen that an increase of 10 lbs. gauge pressure depressed the fluid level 100 feet, which is equivalent to a column density of 9.2* lbs./ square inch/100 feet of fluid height. $\frac{10 \text{ lbs.}}{100 \text{ ft.}} = \frac{9.2 \text{ lbs.}}{100 \text{ ft.}}$

The next pressure increase of 32 lbs. depressed the liquid about 220 feet, indicating a density of approximately 14.5 lbs./square inch/100 feet. The following 64 lb. increase found gas level down 220 feet giving a density of 14.75 lbs./ square inch/100 feet. From these calculations it is apparent that above 20 lbs./square inch gauge pressure, the density in this particular well changes slowly and the most practical purposes can be considered down to the pump. A density of 14.75 is not abnormal to wells making a fair amount of gas. Solid gasless fluid in this well would have a density of about 55 lbs./square inch/100 feet.

In Fig. 4 is plotted the fluid-level heights for this well in the Los Angeles Basin versus the total pressure; using a gas column weight of 10 pounds as the upper fluid level of 3000 feet. This graph indicates that the pressure at the pump is 995 pounds per square inch. In order for the oil in the formation to flow into this well, it must overcome this back pressure of 995 lbs./square inch. For the most efficient oil recovery, the bottom-hole pressure should be reduced as much as possible, and this can be achieved to a large extent by maintaining the lowest practical fluid level. After making changes in pump speed or capacity it is well to run a subsequent fluid-level measurement to be certain that the pump-down is being obtained.

Productivity Index and Well Performance

From the fluid level measurements additional important operating and production data can be obtained. Since the chief function of production oil companies is to work for more efficient oil recovery, the productivity index is of great importance.

The productivity index, defined as "the barrels per day of gross fluid produced per pound per square inch pressure drop at a specific subsurface datum", has proved to be an important factor in determining the productivity of a well. From data secured by use of the bottom-hole pressure gauges described in the early part of this article, a well's productivity index can be obtained by use of either of the following formulas:

(1) Productivity index = $\frac{\text{Gross rate} - \text{Clean rate}}{\text{Producing pressure} - \text{Producing pressure, Clean rate}}$

(2) Productivity index = $\frac{\text{Gross rate} - \text{Clean rate}}{\text{Static pressure} - \text{Producing pressure}}$

When using the Echo-Meter fluid level measurements, the productivity index can be obtained substantially by use of the formula:

(3) Productivity index = $\frac{\text{Gross rate} - \text{Clean rate}}{\text{(Producing fluid height} \times \text{fluid density)} - \text{(Producing fluid height} \times \text{fluid density)}}$

The producing fluid height usually refers to the distance of the fluid level above the pump.

Gross rate — Clean rate

Producing pressure — Producing pressure, Clean rate

Static pressure — Producing pressure

Among formula (2) is the most commonly used, in this case it is very convenient to use the fluid height above the pump. By applying formula (3) to the data from the

Gross rate — Clean rate

(Producing fluid height × fluid density) — (Producing fluid height × fluid density)

Productivity will plotted in Fig. 3 was obtained productivity index as follows:

Pump Elevation

Fluid Level

Producing fluid height as above

Pressure Gauge at 3,140

Producing fluid height as above

Static pressure at 3,140

Producing pressure at 3,140

Gross rate

Clean rate

Productivity index

171170

171170

108 R

Defendant's Exhibit Q—(Continued)

Application Div. Feb. 10 '39 U. S. Patent Office
Mail Division Feb 11 1939 U. S. Patent Office.

State of California
County of Los Angeles—ss.

AFFIDAVIT OF ERNEST K. PARKS

Ernest K. Parks, being duly sworn, deposes and says:

That he is engaged in the practice of petroleum production engineering; that in connection with studies of pumping wells in which mechanical pumps are employed for lifting the oil to the ground surface, it is necessary for him to have information as to the pressure at the pump inlet or at other levels below the liquid surface in the well; that it is desirable for him also to know the density of the fluid in the well and it is desirable for him to determine the production capacity or possibility of the wells operated by the various owners or operators; that he has advised his employers to use, and that they have used, the Depthograph Company to make tests and measurements on at least twenty wells to determine the pressures, densities and production capacities as stated above.

That he is personally acquainted with the inventor, Cranford P. Walker, and is familiar with the methods and apparatus employed by Cranford P. Walker on behalf of the Depthograph Company.

That previous to the introduction to the oil industry by Cranford P. Walker of the sonic method

Defendant's Exhibit Q—(Continued)

of obtaining pressures, densities and production capacity in oil wells, the only method which affiant knew to obtain measurements of the pressure in wells pumping below the level of the fluid therein, was by the use of pressure recorders which were required to be lowered into the well to the desired depth below the level of the oil in the well, which procedure necessitated the removal of at least the sucker rods of the pumping equipment and frequently required the removal of the pump tubing from the well, the attachment of the pressure bomb and the reinsertion of the previously removed pump tubing and/or sucker rods to locate the pressure bomb at the desired level, after which it was necessary to again remove the sucker rods and/or pump tubing to bring the recorder to the ground surface for inspection and reading, all of which operations necessitated stopping of production from the well, both for the purpose of inserting the pressure ~~bomb~~ recorder and for removing the pressure ~~bomb~~. This method produced only information as to the pressures at the pump inlet and did not furnish any information relative to fluid density or the character of the fluid, as regards the relation between the fluid and gas entrapped therein, which was being pumped from the well.

That prior to the introduction to the oil industry of the Walker method there was, to affiant's knowledge, no practicable way in which this fluid density and fluid character could be ascertained.

Defendant's Exhibit Q—(Continued)

That prior to the introduction of the Walker method the only way, to affiant's knowledge, to calculate production capacity of pumping wells was with the use of pressure recorders which required interruption of the production of the well for their insertion and removal as aforesaid.

That the use of the Walker method of obtaining pressure, density and production capacity has greatly facilitated the solution of the problem which to affiant's knowledge petroleum engineers have long been seeking an answer.

That to affiant's personal knowledge the Walker method as aforesaid has saved much time and appreciable expense in determining the information referred to herein.

That affiant first learned of the Walker method of obtaining pressure information, density information and production capacity in pumping wells on or about February, 1936, and this method was employed on wells to his knowledge in Huntington Beach, Montebello, Seal Beach, and Inglewood.

ERNEST K. PARKS.

Subscribed and sworn to before me, this 3rd day of February, 1939.

(Seal) BERNICE VAN GILSE

Notary public in and for the County of Los Angeles, State of California.

My Commission Expires Dec. 10, 1939

Defendant's Exhibit Q—(Continued)
Application Div. Feb 10 '39 U. S. Patent Office.
Mail Division Feb 11 1939 U. S. Patent Office.

State of California
County of Los Angeles—ss.

AFFIDAVIT OF WALTON E. GILBERT

Walton E. Gilbert, being duly sworn, deposes and says:

That he is employed by the Shell Oil Company in the capacity of equipment engineer; that in connection with pumping wells operated by his company in which mechanical pumps are employed for lifting the oil to the ground surface, it is desirable for him to have information as to the pressure at the pump inlet or at other levels below the liquid surface of the well; that it is desirable for him also to know the density of the oil in the well and it is desirable for him to determine the production capacity or possibility of the wells operated by the Shell Oil Company; that the Shell Oil Company has employed the Depthograph Company to make tests and measurements on at least 89 wells to determine the pressures, densities and production capacities as stated above.

That he is personally acquainted with the inventor Cranford P. Walker and is familiar with the methods and apparatus employed by Cranford P. Walker on behalf of the Depthograph Company.

That previous to the introduction to the oil industry by Cranford P. Walker of the sonic method of obtaining pressures, densities and production ca-

Defendant's Exhibit Q—(Continued)

pacity in oil wells, the only method which affiant knew to obtain measurements of the pressure in pumping wells below the level of the fluid therein was by the use of pressure bombs and pressure recorders which were required to be lowered into the well to the desired depth below the level of the oil in the well, which procedure necessitated the removal of at least the sucker rods of the pumping equipment and frequently required the removal of the pump tubing from the well, the attachment of the pressure bomb and the reinsertion of the previously removed pump tubing and/or sucker rods to locate the pressure bomb at the desired level, after which it was necessary to again remove the sucker rods and/or pump tubing to bring the recorder to the ground surface for inspection and reading, all of which operations necessitated stopping of production from the well both for the purpose of inserting the pressure bomb and for removing the pressure bomb.

That prior to the introduction of the Walker method the only way, to affiant's knowledge, to obtain production capacity of gassy pumping wells was with the use of pressure bombs which required interruption of the production of the well for their insertion and removal as aforesaid.

That the use of the Walker method of obtaining pressure, density and production capacity has aided materially in solving the problem for which, to affiant's knowledge, petroleum engineers have long been seeking a solution.

Defendant's Exhibit Q—(Continued)

That affiant first learned of the Walker method of obtaining pressure information, density information, and production capacity in pumping wells on or about October 2, 1936, and this method was employed on wells of this company located in California.

WALTON E. GILBERT.

Subscribed and sworn to before me this 3rd day of February, 1939.

(Seal) M. M. BROWN

Notary Public in and for the County of Los Angeles, State of California

My Commission Expires June 8, 1942

Application Div. Feb 10 '39 U. S. Patent Office.
Mail Division Feb 11 1939 U. S. Patent Office.

State of California
County of Los Angeles—ss.

AFFIDAVIT OF EDWIN B. HALL

Elwin B. Hall, being duly sworn, deposes and says:

That he is employed by The Hall-Baker Co. in the capacity of President; that in connection with pumping wells operated by his company in which mechanical pumps are employed for lifting the oil to the ground surface, it is necessary for him to have information as to the pressure at the pump inlet or at other levels below the liquid surface of

Defendant's Exhibit Q—(Continued)

the well; that it is desirable for him also to know the density of the oil in the well and it is desirable for him to determine the production capacity or possibility of the wells operated by The Hall-Baker Co.; that The Hall-Baker Co. has employed the Depthograph Company to make tests and measurements on at least 30 wells to determine the pressures, densities and production capacities as stated above.

That he is personally acquainted with the inventor Cranford P. Walker and is familiar with the methods and apparatus employed by Cranford P. Walker on behalf of the Depthograph Company.

That previous to the introduction to the oil industry by Cranford P. Walker of the sonic method of obtaining pressures, densities and production capacity in oil wells, the only method which affiant knew to obtain measurements of the pressure in pumping wells below the level of the fluid therein was by the use of pressure bombs and pressure recorders which were required to be lowered into the well to the desired depth below the level of the oil in the well, which procedure necessitated the removal of at least the sucker rods of the pumping equipment and frequently required the removal of the pump tubing from the well, the attachment of the pressure bomb and the reinsertion of the previously removed pump tubing and/or sucker rods to locate the pressure bomb at the desired level, after which it was necessary to again remove the sucker rods and/or pump tubing to bring the recorder

Defendant's Exhibit Q—(Continued)

to the ground surface for inspection and reading, all of which operations necessitated stopping of production from the well both for the purpose of inserting the pressure bomb and for removing the pressure bomb. This method only produced information as to the pressures at the pump inlet and did not furnish any information relative to fluid density or the character of the fluid, as regards the relation between the liquid and gas entrapped therein, which was being pumped from the well.

That prior to the introduction to the oil industry of the Walker method there was, to affiant's knowledge, no way in which this fluid density and fluid character could be ascertained.

That prior to the introduction of the Walker method the only way, to affiant's knowledge, to obtain production capacity of pumping wells was with the use of pressure bombs which required interruption of the production of the well for their insertion and removal as aforesaid.

That the use of the Walker method of obtaining pressure, density and production capacity has solved the problem which to affiant's knowledge petroleum engineers have long been seeking a solution.

That to affiant's personal knowledge the Walker method as aforesaid has saved great quantities of time and appreciable expense in determining the information referred to herein.

That affiant first learned of the Walker method of obtaining pressure information, density information

Defendant's Exhibit Q—(Continued)

and production capacity in pumping wells on or about Sept. 23, 1937 and this method was employed on wells operated by this company located at Wilmington Oil Field, California.

ELWIN B. HALL

Subscribed and sworn to before me this 2nd day of February, 1939.

(Seal) M. M. COLBURN

Notary Public in and for the County of Los Angeles, State of California.

My Commission Expires February 25, 1940

Application Div. Feb. 10, '39. U. S. Patent Office.
Mail Division, Feb. 11 1939. U. S. Patent Office.

State of California,
County of Los Angeles—ss.

AFFIDAVIT OF R. L. KEYES,

being duly sworn, deposes and says:

That he is employed by The Texas Company (Calif.) in the capacity of Assistant Manager of the Producing Department; That in connection with pumping wells operated by his company in which mechanical pumps are employed for lifting the oil to the ground surface, it is necessary for him to have information as to the pressure at the pump inlet or at other levels below the liquid surface of the well; That it is desirable for him also to know the density of the oil in the well and it is desirable for him to determine the production capacity or possi-

Defendant's Exhibit Q—(Continued)

bility of the wells operated by The Texas Company (Calif.); That The Texas Company (Calif.) has employed the Depthograph Company to make tests and measurements on at least thirty-seven (37) wells to determine the pressures, densities and production capacities as stated above.

That he is personally acquainted with the inventor Cranford P. Walker and is familiar with the methods and apparatus employed by Cranford P. Walker on behalf of the Depthograph Company.

That the use of the Walker method of obtaining pressure, density and production capacity has solved the problem which to affiant's knowledge petroleum engineers have long been seeking an answer.

That to affiant's personal knowledge the Walker method as aforesaid has saved great quantities of time and appreciable expense in determining the information referred to herein.

That affiant first learned of the Walker method of obtaining pressure information, density information and production capacity in pumping wells on or about August 1, 1936, and this method was employed on wells of The Texas Company (Calif.) located at Signal Hill and Santa Fe Springs fields in Los Angeles County, and in oil fields in Kern County, California.

(Signed) R. L. KEYES.

Defendant's Exhibit Q—(Continued)

Subscribed and sworn to before me this the 6th day of February, 1939.

SADIE HAWKINS,

Notary Public in and for the County of Los Angeles, State of California.

Mr. commission expires Mar. 26, 1941.

#14

Address Only
The Commissioner of Patents
Washington, D. C.

U. S. Patent Office. Commissioner's Office. Feb. 13, 1939. Copy Mailed.

Department of Commerce
United States Patent Office
Washington

Feb. 13, 1939

Ex parte Cranford P. Walker,
Serial No. 171,170,
Filed October 26, 1937,
Method of Determining Fluid Density,
Fluid Pressure and the Production.
Capacity of Oil Wells.

PETITION TO MAKE SPECIAL

The petition to make this case special has been considered.

If the examiner can make this case special without prejudice to any possible interfering applications, and he should make a rigid search for such,

Defendant's Exhibit Q—(Continued)

he is authorized to do so for the next action. Should the application be rejected again, the case will not be considered special for the subsequent action unless the applicant promptly makes a bona fide effort to place the case in condition for allowance even if it is necessary to have an interview with the examiner to accomplish this purpose.

If the examiner finds any interfering application for the same subject matter, he should consider such application simultaneously with this case and should state in the official letter of such application that he is taking it out of its turn because of a possible interference.

The petition is granted.

JUSTIN W. MACKLIN,
First Assistant Commissioner.

Mr. Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, Calif.

Defendant's Exhibit Q—(Continued)

23-17

Div. 36
Cranford P. Walker,
Serial No. 171,170

The examiner will please send the file of this application to ~~Mr. E. T. Newton, Room 3628~~ Mrs. Peterson, Room 3898, indicating hereon when the application will be reached for action.

CONWAY P. COE,
Commissioner.

This application will be acted upon April 3, 1939.

Date Feb. 13, 1939.

M. BUCHLER.
(To be signed by person reporting.)

Defendant's Exhibit Q—(Continued)

Div. 36 Room 7892

260

Buchler:mwc

Address only

"The Commissioner of Patents,

Washington, D. C.,"

and not any official by name

Paper No. 15

All communications respecting this application should give the serial number, date of filing, and name of the applicant

Department of Commerce

United States Patent Office

Washington

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,

Commissioner of Patents.

Harold W. Mattingly,
924 Pacicif Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 171170.
Filed Oct. 26, 1937

For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

Responsive to amendment filed January 3, 1939. It was understood that the Applicant intended to

Defendant's Exhibit Q—(Continued)

file a supplemental amendment and the examiner has waited a reasonable time for the filing of such amendment. However, in view of the fact that this application has been made special, it is taken up for examination at once.

In line 1 of page 13, "10" should be 12.

The drawing should show a pressure gage connected to the casing head.

Claims 12 to 17, 23 to 33, 35 to 38, and 39 to 45 are in the case.

Claims 12 to 17, inclusive, are rejected on the ground of misjoinder of invention. In the second Office action, division between claims 12 to 17 and another group of claims was made final after approval of the Examiner of Classification. In response to the second Office action, Applicant did not elect to prosecute claims 12 to 17.

The requirement for election of species in the last Office action has been traversed by applicant on the ground that the claims did not fall within the groups as stated in said action. Said requirement has been submitted to the Examiner of Classification who states:

"Division has been required under Rule 41 between:

I. Claims 24, 25, 35, 36, 44 and

II. Claims 23, 37, 38, 45.

There appear to be no generic claims, the remaining claims in the case, 26-33 and 39-43, being sub-generic, and claims 12-17 being retained under Rule 42.

Defendant's Exhibit Q—(Continued)

The groups cover mutually exclusive species and division is approved, pending the non-allowance of a generic claim."

With the approval of the Examiner of Classification, the requirement for division between (I) claims 24, 25, 35, 36, 44 and (II) 23, 37, 38, 45 is now Made Final.

Upon reconsideration of this application in the light of the last amendment, it is found that the novel method disclosed is that of measuring the density of the standing column of liquid existing between the well casing and tubing string 5. Accordingly claim 28 is allowable.

Claims 26, 30 and 33 are rejected as being non-inventively different from claim 28, all of these claims differing from each other only by verbiage.

Claims 27, 29 and 31 are rejected as being incomplete because the step of measuring the level of the liquid surface after the pressure in the well has been changed, is not included. Apparently the new stable level of liquid must be measured after the pressure has been changed in order that the density may be determined. The claims should include all essential steps.

Claims 30 and 32 are further rejected as incomplete because the steps of measuring the liquid surface levels are not included.

Claims 31 and 32 are further rejected as incomplete because each fails to state that the liquid operated upon lies between the pump tubing and

Defendant's Exhibit Q—(Continued)

the well casing. A perusal of Applicant's specification reveals that the method of measuring density must be performed upon the standing column of liquid between casing 1 and tubing 5. The method would not apparently be operative when performed on the liquid within tubing 5. The claims should therefore state that the levels measured are those of the surface of liquid between casing 1 and tubing 5.

Claims 39 and 40 are rejected as covering only common sense ways of measuring pressure at a point in the liquid in an oil well.

Claim 39 is further rejected as unpatentable over page 194 or the 1931 volume or pages 353 and 354 of the 1932 volume
^ the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, each of record. Applicant states that the pressure of a point in the liquid in a flowing well varies as the depth below the surface and he further states that the density of the liquid in a flowing well varies as the depth. These facts are immaterial as far as claim 39 is concerned because the steps of this claim merely result in the determination of the pressure at the liquid surface. Therefore, it would not be invention to use the methods of these references to determine the pressure in a pumped well.

Also, Applicant states that page 194 does not apply because this reference states how the pressure at the bottom and the bottom only may be

Defendant's Exhibit Q—(Continued)

determined. The bottom may be the desired one of "and desired level" below the normal surface of the liquid and therefore claim 39 is anticipated.

Claim 40 is further rejected as unpatentable over pages 353, 354, and 359 of the 1932 volume or page 194 of the 1931 volume of the Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology, each of record. It would not be invention to use the methods disclosed by these references to determine the pressure in the liquid in a pumped well. If the density of the liquid in a flowing well does vary with the depth, it is not apparent how this fact affects the patentability of the claim. The mere discovery of a scientific truth or fact is not proper subject matter of a patent. The method appears to be the same whether applied to a flowing well or to a pumped well, the main difference being that Applicant has found that the method is more easily applied to a pumped well.

Claims 41 and 43 are objectionable since these claims include many surplus steps. In order to determine only liquid pressure, it is not necessary that the casing pressure and level be altered, etc.

Since claims 41 and 43 merely determine liquid pressure at any desired level, these claims are rejected as unpatentable over the references applied to claims 39 and 40 for the reasons stated above in the rejection of claims 39 and 40.

Claim 43 is further rejected as misleading. How

Defendant's Exhibit Q—(Continued)

may the casing head pressure be noted as stated in the second step if the casing is not closed as inferred from the third step.

Claim 42 is rejected as unpatentable for the reasons stated above in the rejections of claims 39 and 40.

As stated above, the novelty in this case appears to reside in the method of measuring density as stated in allowed claim 28. The method of determining pressures appears to involve only obvious steps of computation or operation of the well and this method does not appear to be patentable.

The description should be amended to state more clearly that the density, pressure, etc. are determined by performing operations in connection with the column of fluid between casing 1 and tubing 5.

A. D. McFADYEN,
Examiner.

Submitted Feb. 24, 1939. Supervisory Examiner.

Defendant's Exhibit Q—(Continued)

Application Div., U. S. Patent Office. Mar. 6, '39.

U. S. Patent Office. *Mar 6 1939* Division 36.

In the United States Patent Office.

Division 36—Room 7892

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Filed October 26, 1937.

Serial No. 171,170

Los Angeles, California

March 3, 1939

Hon. Commissioner of Patents

Washington, D. C.

Sir:

In response to the Office action of February 24, 1939, please amend the above identified application as follows:

Page 1, Line 21, change "50-150" to read—50 to 150 feet—.

Page 5, Line 1, after "be" insert—either—; same line, after "to" cancel "either"; Line 18, before "liquid" insert—standing column of—; Line 20, cancel "the well" and substitute—such column—; Line 22, before the period insert—by the usual pumping apparatus employed therein—; Line 25, cancel "fluid"; same line, after "surface" insert —of the standing column of liquid in the well—; Line 29, cancel "producing"; same line, before the

Defendant's Exhibit Q—(Continued)

period, insert—being produced by a mechanical pump—.

Page 6, cancel from Line 12 through Line 4 on Page 7.

Cancel from Line 23 on Page 7 through Line 2 on Page 8 and substitute the following:

(D1)

—Another object of my invention is to provide a ready method for determining the potential production capacity of a well by determining the liquid pressure at some point below the liquid surface in the well, either at the pump inlet or any other location, under two conditions of production from the well (one of which may be zero production), and by comparing the pressures so determined with the production rates, determining the maximum potential production obtainable from the well.—

Page 9, Line 10, change "the" to read —a—.

Page 11, Line 5, after "surface" insert —of the "standing column" of liquid within the well—; Line 9, after the period, insert

(D2)

—The expression "standing column" as used herein is intended to mean the column of liquid which stands in the well as distinguished from the pumped liquid column which is being lifted to the ground surface by the pump, such standing column being known in the oil industry as the "dead" liquid column and with the usual type of pumping appa-

Defendant's Exhibit Q—(Continued)

ratus this standing column lies in the annular space between the tubing 5 and the casing 1.—; Line 18 before "well" insert

—annular space between the tubing 5 and the—; Line 25, after the comma, insert —as by means of a pressure gauge 13,—.

Page 12, Lines 25 and 29, after "chart" insert —shown in Fig.—.

Page 13, Line 1, change "10" to read —12—; Line 11, change "multiplied by 3" to read —represented at 3a (Fig. 2)—.

Page 14, Line 2, change "fluid" to read —standing column of liquid mixture of oil and gas—; Lines 4 and 11, after "chart" insert —shown in Fig.—; Line 23, change "oil" to read —liquid—.

Page 15, Line 3, change "fluid" to read —liquid—; Line 5, change "oil" to read —liquid mixture of oil and gas—; same line, after "well" insert

(D4)

—(that is, the pressure exerted by this mixture per unit of height of the column of liquid mixture)—; Line 9, change "oil" to read —liquid—.

Page 16, Line 15, change "fluid" to read —liquid—; same line, correct the spelling of "corresponding".

Page 17, Line 3, change "fluid" to read —liquid—; Line 5, after the period, insert

(D5)

—I have discovered that in wells employing mechical pumps for any given production rate by the

Defendant's Exhibit Q—(Continued)

pump, the density of the oil and gas mixture is constant throughout the height of the standing column of liquid in the annular space between the tubing and casing so that the line C once established continues as a straight line, the effect in pressure per unit of height of the column being constant throughout the height of the column.—

Cancel Claims 12 through 27, 30, 32, 33, 35 through 40, and 42 through 45.

Rewrite Claim 28 as follows:

(D6)

2—~~46~~. The method of determining the density of liquid in a well having a casing and a pump suspended therein on tubing and without requiring removal of pump parts, which consists in determining the liquid level in the annular space between the pump tubing and the casing under one condition of pressure, changing the pressure of the gas within the well to move the liquid surface to a new stable level, measuring the new level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference between the two levels.—

Rewrite Claim 29 as follows:

(D6)

3—~~47~~. The method of determining the density of the standing column of liquid in a well having a casing and a pump suspended therein, which consists in measuring the level of the standing column of liquid in the well while the pump therein is op-

Defendant's Exhibit Q—(Continued)

erated at a given rate of production and under a known condition of gas pressure on the surface of the liquid column, changing the gas pressure on the liquid column, continuing the operation of the pump at the same production rate until the level of the standing column becomes stable at a new location, measuring the new level and comparing the difference in the pressures exerted on the liquid surface at the two levels with the difference in hight of the two levels.—

Rewrite Claim 31 as follows:

(D6)

~~4~~—~~48~~. The method of determing the density of the standing column of liquid in a well having a casing and a pump suspended therein, which consists in measuring the stable level of the surface of the standing column of liquid under one condition of pressure of gas released by the well, measuring the pressure on said liquid surface under said one condition of gas pressure, regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level, measuring the new level, measuring the pressure on the liquid surface at the new level, and comparing the difference in the pressures exerted upon the liquid surface under the two conditions of gas pressure with the difference in height of the levels of the liquid surface under the two pressure conditions.—

Defendant's Exhibit Q—(Continued)

Add the following claim:

(D7)

5—~~49~~. The method of determining the density of the standing column of liquid in a well, which comprises measuring the stable level of the liquid column under one condition of gas pressure, changing the pressure of gas within the well to move the surface of the liquid column to a new stable level, measuring the new stable level and dividing the change in pressure on the liquid surface required to achieve the new level by the difference in height between the two levels.—

Claim 41, cancel from "liquid" in Line 1 through "liquid" in Line 2, and substitute the following: —density of the standing column of liquid—; Line 5, cancel "the pump" and substitute —pump parts—; Line 11, after "pump" insert —at the same rate of production—; Line 14, change "noting" to read —measuring—; Line 19, cancel "gas".

Add the following claims:

(D8)

6—~~50~~. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of liquid in the well at any desired level below the normal surface of said column and without requiring the removal of any of the pump parts, which comprises measuring the actual stable level of the liquid column under one known condition of gas pressure in the casing, determining the pressure on the liquid surface at that level, changing the pressure of gas in the well to move the surface of said

Defendant's Exhibit Q—(Continued)

column to a new actual stable level, measuring the new level of the liquid surface, determining the pressure on the liquid surface at the new level, determining the density of the liquid by dividing the change in pressure on the liquid surface required to achieve the new level by the difference in height of the two levels and computing the unknown pressure at the desired level by adding to the pressure on the liquid surface at either of the levels the effect in pressure of the column of liquid of the density so determined between the selected actual level and the desired level.

7—~~51~~. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted by the standing column of liquid at any desired level below the normal surface of said column while the pump is operating to remove liquid from the well, which comprises measuring the actual stable level of the liquid under one known condition of gas pressure in the well by sonic sounding method, determining the pressure on the liquid surface at that level, changing the pressure of the gas in the well to move the surface of the column to a new actual level, continuing to operate the pump at the same production rate as for the first condition of gas pressure in the well until the liquid level again becomes stable, measuring the new stable level and determining the pressure upon the liquid surface at this new level, determining the pressure exerted per unit of height of the liquid column by

Defendant's Exhibit Q—(Continued)

dividing the change in gas pressure on the liquid surface required to effect the change in the liquid level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the gas pressure upon the liquid surface at either of the actual levels the effect in pressure of the liquid column between the selected actual level and the desired level.

8—52. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises measuring the stable level of the surface of the standing column of liquid in the well at one known rate of production and under one known condition of gas pressure in the well, determining the pressure on the surface of the liquid column at that level, changing the gas pressure in the well to move the surface of the liquid column to a new stable level, measuring the level of the liquid surface under the new gas pressure condition and determining the pressure on the liquid surface at the new level, dividing the change in pressure on the liquid surface by the difference in height between the two levels to thereby determine the density of the liquid in the column at that rate of production, determining the pressure at some predetermined desired point below the normal liquid surface for that rate of production by adding to the pressure on the liquid surface for either of the measured levels the effect in pressure of the column of liquid between that level and the predetermined desired point, then changing the rate of

Defendant's Exhibit Q—(Continued)

production by the pump and repeating the liquid level change and gas pressure determinations to determine the density of the liquid in the column and the pressure of the liquid at the said predetermined desired point for the new rate of production and then dividing the difference in the two production rates by the difference in the corresponding liquid pressures at the desired point and using the ratio thus found to determine the maximum rate at which the well is capable of being produced.—

REMARKS

In making the foregoing amendments, the applicant sincerely appreciated the action entered by the Examiner on February 24, 1939 and wishes to express apologies for being unable to have completed this amendment prior to the entry of that Office action. However, it is believed that the entry of the Office action of February 24, 1939 clarifies the situation with regard to this case so that this amendment may place this case in condition for an immediate allowance.

In making the foregoing amendments, the applicant has attempted to conform exactly with the discussion had with the Examiner in charge of this application, the Primary Examiner of this division and the Supervisory Examiner at the oral interviews had during the week of February 6, 1939 and it is believed that the Examiner will find that each of the claims now presented in this application pre-

Defendant's Exhibit Q—(Continued)

sents the subject matter which was discussed and agreed upon as allowable in this case.

However, for the assistance of the Examiner in considering the claims, all of the claims have been rewritten in this amendment in order to gather them together in one place, new Claim 46 representing old Claim 28 which was indicated as allowable by the Supervisory Examiner. The only alteration which has been made in Claim 46 over the exact wording of Claim 28 has been in leaving out the word "and", first occurrence, from Line 2 of Claim 28, this word being entirely unnecessary and merely acting to confuse the claim.

New Claim 47 is old Claim 29 rewritten in accordance with the changes suggested at the oral interviews for the purpose of making this claim more complete.

At this point it should be noted that upon the consideration of this application at the oral interviews it was pointed out to the Examiner that whereas the Examiner had apparently misunderstood the action which takes place in the oil well under the applicant's method of determining density and had considered that increasing pressure upon the liquid surface would displace the liquid by driving it back into the formation, the actual conditions which do prevail in an oil well which is being pumped by a mechanical pump are that the standing column of liquid (that is, the column of liquid in the annular space between the pump tubing and the casing) is substantially the same density throughout its height,

Defendant's Exhibit Q—(Continued)

this condition existing because of the fact that the standing column of liquid is a mixture of gas and oil in which the gas bubbles are smaller in the lower portion of the column than close to the surface of the column while the rate at which the bubbles are moving through the column increases as these bubbles approach the surface. Hence, though the bubbles close to the surface are larger, they are traveling at such a rapid rate that their effect as regards the density of the column is the same at or near the surface of the column as they are further down in the column.

The applicant takes advantage of this constant density (or, as may be expressed in another way, the effect in pressure per unit of height of the colum, is constant throughout the standing column) by first measuring some one stable level of this standing column and then changing the location of the surface of the column, either by increasing the pressure of gas on the liquid surface or decreasing the pressure on the liquid surface, thus providing a measure of the density of the liquid in the column without changing the rate of flow of the oil and gas mixture from the formation. This method of determining that density of the dead liquid or standing column of liquid is not disclosed in any of the references of record, the only density measurements referred to in the references being directed to the use of pressure bombs which are inserted in the well after the removal of the pump

Defendant's Exhibit Q—(Continued)

and tubing from the well and the applicant has therefore provided a new and novel means of determining this density.

Upon the presentation of this explanation to the Examiner, the Primary and the Supervisor, it was agreed that this is a new and novel method and that claims defining this along the lines of original Claim 28 would be considered as allowable over the references of record.

Upon reviewing Claims 27, 29, 30, 31, 32 and 33 with the Examiner, it was found that a number of essential steps had not been definitely recited and it is for this reason that the applicant has carefully reviewed these claims and has substituted for them Claims 47, 48 and 49.

Claim 47 expresses the same subject matter as original Claim 28 (now Claim 46) but with the limitation that the measurements are made while the pump is operating at a given rate of production, and including the additional step that after the change in the level of the standing column has been achieved the pump is again operated at the same rate of production until the column becomes stable at the new level.

In connection with the consideration of the new Claims 47 through 52, the Examiner's attention is called to the fact that each of these claims describes the particular kind of fluid column upon which the measurements are to be made as the "standing column of liquid" in the well, the specification having been amended to accurately and definitely describe

Defendant's Exhibit Q—(Continued)

this standing column of liquid as that column of liquid which exists in wells that are being pumped and which column of liquid lies in the annular space between the casing and the tubing as distinguished from the fluid which has passed through the pump and which may now be terms "pumped fluid". It is, of course, understood and is explained in the specification that with present day types of pumps the standing column lies in the annular space between the tubing and the casing but might equally as well occupy some other space in the well where conditions were reversed and the annular space was used for the passage of the pumped liquid. In either event, however, the expression "standing column of liquid" as defined in the specification would be an accurate expression of exactly that portion of the liquid in the well upon which applicant's method is practiced.

New Claim 48, which represents old Claim 31 rewritten, defines the same subject matter as Claim 28 (now Claim 46) with the limitation that the change in the location of the liquid level is brought about by the gas which is released from the well and includes the step of "regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level. It is believed that this claim clearly and patentably distinguishes from both Claims 26 and 27.

New Claim 49 is directed to the same subject mat-

Defendant's Exhibit Q—(Continued)

ter as old Claim 28 but expresses the invention in somewhat different language, this claim including each of the steps set forth in Claim 28 and this claim was indicated by the Examiner to be an allowable expression of the invention.

Claim 41 has been amended, as indicated in the Office action of February 24, 1939, to define the invention in terms of "density" instead of in terms of pressure, this claim having originally been inaccurately worded. It is believed that the amendments in this claim accurately and completely express each of the necessary steps of the method which was found to be allowable in Claim 28.

Claims 50 and 51 are directed to the applicant's method of obtaining the pressure at various or any point below the surface of the standing column of liquid in the well, which includes the steps of first determining the density of the column and then employing that information to compute the pressure which will exist at the desired or unknown level. Claim 50 expresses this subject matter in terms of density measurement while Claim 51 expresses this subject matter in terms of "pressure exerted per unit of height of the liquid column".

Claim 52 is directed to the employment of the applicant's method of obtaining density measurements in the liquid column for the purpose of computing the maximum production capacity of the well.

The subject matter of Claims 50, 51 and 52 was considered by the Examiner at the oral interviews and was indicated as clearly allowable over the ref-

Defendant's Exhibit Q—(Continued)

erences in that they employ the new and novel method of obtaining the density measurements by which the density measurements or computation of pressure and production capacity could be made.

In accordance with the suggestion made by the Examiner, permission is requested to amend the drawings in this application as indicated in red ink on the accompanying print.

It is believed that the foregoing amendment, limiting the claims of this application to the subject matter which was discussed with the Examiner and which was as pointed out above clearly patentable over any of the references of record, places this case in condition for immediate allowance, which action is respectfully requested.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant

HWM:MM

Defendant's Exhibit Q—(Continued)

#17

U. S. Patent Office Mar 6 1939 Division 36
Application Div. Mar 6 '39 U. S. Patent Office.

In the United States Patent Office
Division 36 — Room 7892
Account

Cranford P. Walker
Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

Filed October 26, 1937
Serial No. 171,170

Los Angeles, California
March 3, 1939

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Attention: Office Draftsman

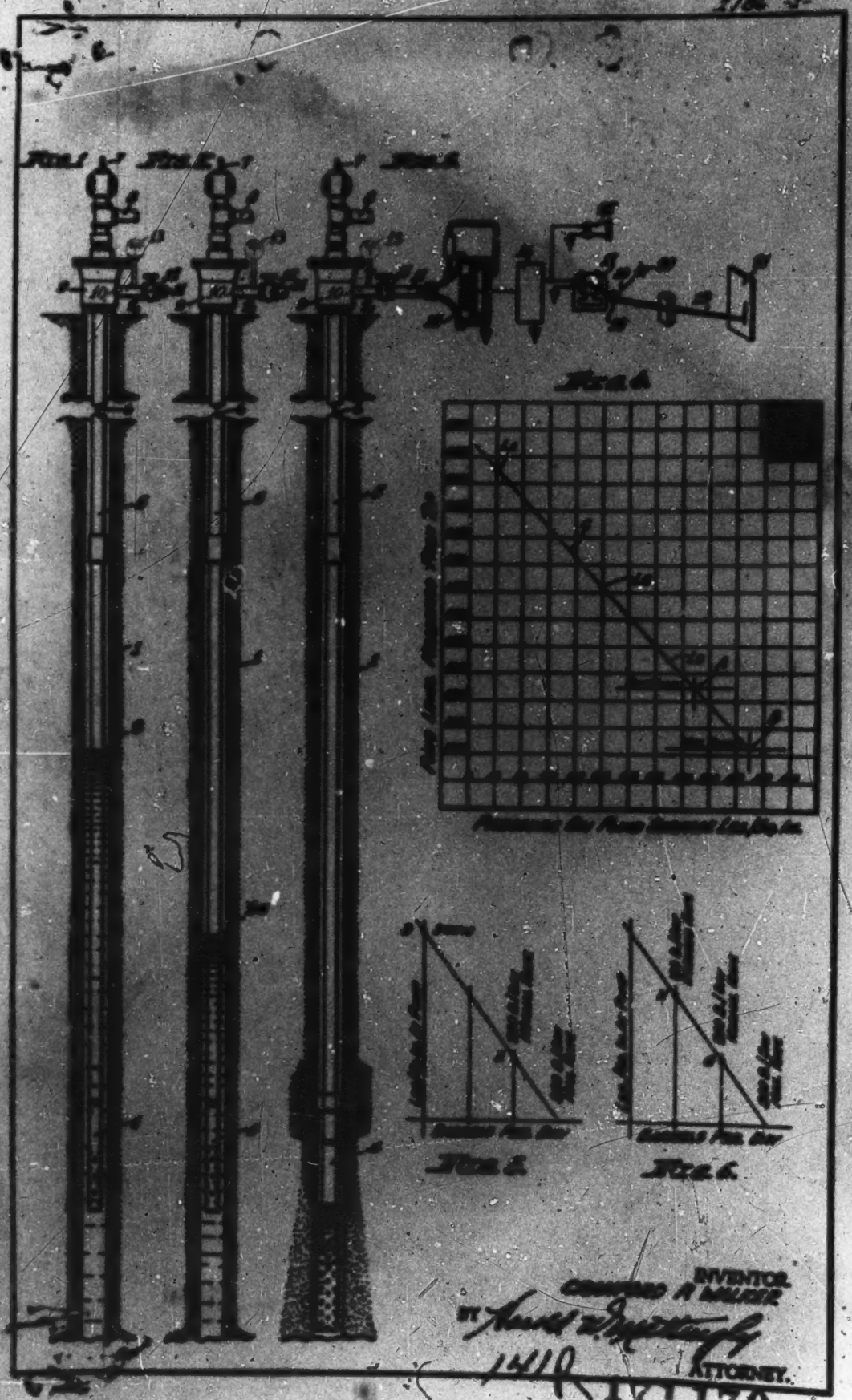
Please instruct the Office Draftsman to make the changes indicated in red ink in the accompanying print.

Please charge the cost of making this change to my miscellaneous fees account.

Respectfully submitted
HAROLD W. MATTINGLY
Attorney for Applicant

Approved, M. B. Div. 36, March 7, 1939.
Received in Div. C Mar 8 1939.
Correction ordered Mar 8 1939 Account 5W.
Div. C Corrected Mar 8 1939.

HWM:MM



INVENTOR.
CHESTER A. BELDEN
BY
ATTORNEY.

1411

171170

Defendant's Exhibit Q—(Continued)

Div. 36 Room 7892

Buchler:mwc

Department of Commerce
United States Patent Office
Washington

Paper No. 18

All communication respecting this application should give the serial number, date of filing, and name of the applicant

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

Mailed Mar 14 1939.

Please find below a communication from the EXAMINER in charge of this application

CONWAY P. COE
Commissioner of Patents.

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Applicant Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937
For Method of Determining Mining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

In accordance with the provisions of Order No.

Defendant's Exhibit Q—(Continued)

2308, dated March 12, 1917, which reads in part as follows:

* * * * * * * * *

Obvious informalities in the application may be corrected by the examiner, but said correction must be in the form of an amendment, approved by the Principal Examiner in writing, placed in the file, and made a part of the record. The changes specified in the amendment will be entered by the clerk in the regular way.

* * * * * * * * *

the changes, hereinafter specified, are made by the examiner in the application above identified.

Should these changes not be satisfactory to the applicant, appropriate amendment may be proposed under the provisions of Rule 78, provided the specification has not been printed.

The application has been amended as follows:

In line 19 of claim 51, by the difference in height of the two levels has been inserted after "level".

A. D. McFADYEN
Examiner.

Defendant's Exhibit Q—(Continued)

[Printed in Margin]: In Remitting the Final Fee Give the Serial Number at the Head of This Notice.

[Printed in Margin]: Uncertified Checks Will Not Be Accepted.

181

Div. 36-Rm 7892-mwc

Serial No. 171170

Mailed Mar 15 1939.

Department of Commerce
United States Patent Office
Washington
Address Only
The Commissioner of Patents
Washington, D. C.

March fifteenth, 1939

Cranford P. Walker,

Your Application for a patent for an Improvement in Method of Determining Fluid Density Fluid Pressure and the Production Capacity of Oil Wells filed Oct. 26, 1937 has been examined and Allowed with 8 claims.

The final fee, Thirty Dollars, With $1 Additional for Each Claim Allowed in Excess of 20, must be paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld, but the application may be renewed within one year after the date of the original notice with a renewal fee of $30 and $1 additional for each claim in excess of 20.

Defendant's Exhibit Q—(Continued)

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, Distinctly and Plainly Written, the name of the Inventor, Title of the Invention, and Serial Number as Above Given, Date of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names of the Assignees.

If it is desired to have the patent issue to an Assignee or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Defendant's Exhibit Q—(Continued)

Notice.—When the Number of Claims Allowed Is in Excess of 20, No Sum Less Than $30 Plus $1 Additional for Each Claim in Excess of Twenty Can Be Accepted as the Final Fee.

Respectfully,

CONWAY P. COE

Commissioner of Patents.

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Walter P. Huntley MAdison 1137

Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
621 South Hope Street
Los Angeles, California

Apr-3-39 197020 D—Check—30.00
Mail Division Apr 3 1930 U. S. Patent Office.

March 30, 1939

Commissioner of Patents
Washington, D. C.

Sir:

Enclosed herewith please find my check No. 1133 in the sum of $30.00 to cover the final Government fee in the matter of the application for United States Letters Patent for Method of Determining

Defendant's Exhibit Q—(Continued)

Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

Name of Inventor: Cranford P. Walker

Serial No. 171,170

Filed October 26, 1937

Allowed March 15, 1939, with 8 claims.

Respectfully,

HAROLD W. MATTINGLY

MM

#19

Div. 36—Room 7892

U. S. Patent Office Apr 18 1939 Issue Division.

Rule 78 Apr 18 1939 Orders No. 2698, 2801, 3311.

In the United States Patent Office

In re Application of

Cranford P. Walker

Serial No. 171,170

Filed October 26, 1937

Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

Washington, D. C., April 18, 1939.

Hon. Commissioner of Patents,

Washington, D. C.

Sir:

Amendment Under Rule 78

Please amend the above-entitled application as follows:

Cancel Fig. 3.

Defendant's Exhibit Q—(Continued)

In the specification, page 8, omit description of Fig. 3 and change Figs. 4, 5 and 6 to read —Figs. 3, 4 and 5—.

Page 12, change "Fig. 4" to read —Fig. 3— in lines 15, 25 and 29.

Page 13, line 7, after "to" insert —three times the length of—.

Page 14, lines 4 and 11, change "Fig. 4" to read —Fig. 3—.

Page 16, lines 10 and 26, change "Fig. 4" to read —Fig. 3—.

Page 17, line 26, change "potential" to read —rates of—.

Page 19, lines 4, 9, 22, 24 and 27, change "Fig. 5" to read —Fig. 4—.

Page 20, line 21, change "Fig. 6" to read —Fig. 5—.

Delete from line 15, page 21, through line 10, page 24.

Page 24, line 27, cancel "of the pump".

REMARKS

This amendment is requested to delete all reference to Figure 3 including the description thereof in the specification.

It will be noted that division was required in this case between the subject matter of Figure 3 and the remaining matter and a divisional application is being filed before issue of this application to cover said Figure 3.

Defendant's Exhibit Q—(Continued)

Under the common practice, the Office should have required cancellation of all reference to Figure 3 and the applicant is now seeking to do what should have been done in accordance with the accepted practice.

In view of the fact that said divisional application may remain pending for an appreciable period of time, it would seriously affect applicant's commercial efforts and disclose to the public, without claims thereto, the modification shown in said Figure 3.

Respectfully submitted,

RAYMOND JONES,

Associate Attorney.

Defendant's Exhibit Q—(Continued)

Div. 36 Room 7892

1-b

Buchler:mwc

Paper No. 20

Address only

"The Commissioner of Patents
Washington, D. C.",
and not any official by name

All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Mailed Apr 18 1939

Department of Commerce
United States Patent Office
Washington

April 18, 1939

Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 171170
Filed Oct. 26, 1937
For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

The entry of the amendment proposed under Rule

Defendant's Exhibit Q—(Continued)

78 has been disapproved. A copy of the examiner's adverse report appears below.

CONWAY P. COE,
Commissioner of Patents.

The specification has been printed and the drawing has been photolithographed so that it is too late to eliminate a figure from the disclosure.

E. D. BROMLEY,
Actg. Examiner.

Approved Apr 18 1939.

HENRY VAN ARSDALE,
Asst. Commissioner of Patents.

Defendant's Exhibit Q—(Continued)

#21

Application Div. Apr 20 '39. U. S. Patent Office.

In the United States Patent Office
Division 36—Room 7892

Cranford P. Walker,
Method of Determining Fluid
Density, Fluid Pressure and
the Production Capacity of
Oil Wells,
Serial No. 171,170
Filed October 26, 1937

U. S. Patent Office Apr 20 1939 Issue Division

Los Angeles, California
April 18, 1939

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

I hereby abandon the above entitled application.

Respectfully submitted,
CRANFORD P. WALKER,
Inventor.

[Longhand Notation] Any assignment? No assigt received including Apr. 18, 1939. Spielman.

[Stamped]: Abandoned 4/20/39m 4/20/39L.

Defendant's Exhibit Q—(Continued)

ABS
#22

April 21, 1939

Mr. Cranford P. Walker,
Care Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, California.

My dear Mr. Walker:—

I have your letter of Abandonment in connection with your application filed October 26, 1937, for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, Serial Number 171,170, allowed on March 15, 1939.

The application has been marked Abandoned in accordance with your request.

Sincerely yours,
J. A. BREARLEY,
J. A. BREARLEY,
Chief Clerk.
L (Div B)

171170—22

Docket Division Aug 10 1939 U. S. Patent Office
Washington, D. C.
Aug. 10, 1939

PETITION FOR ACCESS

Hon. Commissioner of Patents
Washington, D. C.

Access to the application of C. P. Walker, Serial

Defendant's Exhibit Q—(Continued)

No. 171,170, is requested for the purpose of making copies of certain papers in the file.

Application Serial No. 171,170 is the parent case of which the C. P. Walker patent No. 2,161,733, is a continuation.

Respectfully,

MARIE A. AHERN.

O. K. H. S. M. Aug. 12, '39

171170—23.

Docket Division Oct 15 1941 U. S. Patent Office

Law Offices

Earle D. Crammond

Patent and Trade Mark Causes

Earle Building

Washington, D. C.

District 9899

October 13, 1941.

Hon. Commissioner of Patents,

Washington, D. C.

Sir:

Permission is hereby requested for access to the file of the application of Cranford P. Walker, Serial No. 171,170, filed Oct. 26, 1937. This application is referred to in patent Reissue 21,383, in the second paragraph of page 1. Reissue 21,383 is involved in Civil Action 1655-H, Southern District of California. In order to properly prepare the defenses in the aforesaid law suit, access to the

Defendant's Exhibit Q—(Continued)

above noted application must be had, for the purpose of making certified copies.

Very respectfully,

E. D. CRAMMOND.

EDC:I

O. K. 10/15/41.

A. F. ROHRMAN.

421

1937

CONTENTS

1. Application.....papers.
2. Print Oct-30-37
3. Rejection (Division) Feb 5 1938
4. Amdt A Apr-25-38
5. Reg. Div. Approved in Part. June-16-38
6. Asso Pr Atty Apr-28-38
7. Final Action (Division) Jun 20 1938
8. Letter July-9-38
9. Amdt B Oct-5-38
10. Rejection Nov 1-1938
11. Amdt C Jan-3-39
12. Approval Reg. Div. Feb-8-39
13. Petition to Make Special Feb-11-39
14. Petition Granted Feb-13-39
15. Rejection Feb 24 1939
16. Amdt D Mar-6-39
17. Letter (draft) Mar-6-39

Defendant's Exhibit Q—(Continued)

18. Ex. Amdt E Mar-14-39
19. Amdt (Rule 78) Apr 18-39
20. Adverse Notice Sent Apr 18-39
21. Letter April-20-39
22. Petition for access Aug 10, 1939
23. Petition for Access Oct 15, 1941

[Endorsed]: Filed Nov. 9, 1942.

DEFENDANT'S EXHIBIT R

390

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of File Wrapper and Contents, in the matter of the

Letters Patent of
Cranford P. Walker,

Number 2,161,733, Granted June 6, 1939.

for

Improvement in Methods of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this eighth day of May, in the year of our Lord one thousand nine

Defendant's Exhibit R—(Continued)

hundred and forty-two and of the Independence of the United States of America the one hundred and sixty-sixth.

Attest:

[Seal]

D. E. WILSON,
Chief of Division.

CONWAY P. COE,
Commissioner of Patents.

Defendant's Exhibit R—(Continued)
Mail Division Apr 19 1939 U. S. Patent Office
1/86
Apr-19-39 211447 D —Check—
U. S. Patent Office Apr 26 1939 Division 36

PETITION

To the Commissioner of Patents:

Your petitioner, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and the State of California, whose post office address is 2824 Carlaris Road, San Marino, California, prays that Letters Patent may be granted to him for the Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells set forth in the annexed specification, and he hereby appoints

Harold W. Mattingly
720 Pacific Finance Building
621 South Hope Street
Los Angeles, California
(Registry No. 12,385)

his attorney, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

(Sign here first name in full)

CRANFORD P. WALKER.

Defendant's Exhibit R—(Continued)

SPECIFICATION

To All Whom It May Concern:

Be It Known, That I, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and State of California, have invented certain new and useful improvements in Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells of which the following is a specification:

My invention elates to methods of determining the fluid density fluid pressure and potential production capacity of oil wells and has particular reference to methods of determining the most desirable character of pumping equipment and manner of operating the same to permit an efficient production, of oil from a given well.

This application is a continuation of my copending application Serial No. 171,170, filed October 26, 1937.

It is the common practice in oil well production activity to permit an oil well to produce as a flowing well, that is, to permit the oil to flow out at the ground surface due to the pressure in the oil formations, until the production rate reaches a considerably low value or ceases, after which gas lifting is usually attempted and continued until the production rate with gas lifting reaches a relatively low value or the production entirely ceases. At this time, and in some instances prior to any attempt to gas lift the oil, mechanical pumping devices are usually installed to lift the oil by mechanical means to the surface, these pumps usually comprising a pump

Defendant's Exhibit R—(Continued)

barrel located at a considerable depth in the well, usually 50 to 150 feet below the surface of the liquid in the well while it is producing, plungers or other reciprocating devices being employed in the barrel and operated from the ground surface by means of sucker rods.

Usually the selection of the size and character of the pumping equipment is determined by the production of the well during its flowing or gas lifting life by estimating from this production the type or character of pump which appears to be most suitable. In many fields, however, the type, size and character of the pump installed is usually one determined as "standard" for that particular type of well in the particular field. In other words, it is one having the same dimensions as pumps in other wells producing from the same horizon. Frequently, such well receives no further attention until the field as a whole has declined to a point where it becomes necessary to increase the production from the wells, as for example, by the encroachment of water, necessitating the lifting of greater quantities of fluid in order to obtain the desired amount of oil. When this condition occurs, it is customary to increase the capacity of the pumping equipment.

Also, the production from a given well may be believed to be less than the character of the well and the character of the pumping equipment employed should indicate, as for example, the pump may be operating at a relatively low volumetric efficiency.

In order to determine whether or not any change in the size, character, operating characteristics or

Defendant's Exhibit R—(Continued)

location of the pumping apparatus should be made, it is desirable that the location of the liquid surface, the character of the liquid in the well, its density and the fluid pressure at any given point below the surface of the liquid and the maximum potential production capacity of the well should be determined.

For example, if the pumps in a particular field are operating at good volumetric efficiency, much can be determined from the quantity of oil produced and the volumetric displacement per stroke of the pump, and if the pumps are operating at their maximum capacity, the fact that the fluid level is at a considerable distance above the pump inlet may indicate that the operator is justified in making a change in the size or character of the pumping equipment. Again, if the volumetric efficiency of the pump is found to be low, as for example, when the pump appears to be taking in a comparatively large quantity of gas upon each stroke of the pump, the operator should know whether or not the inlet of the pump is located at a point too near the liquid surface so that he may determine how far below the liquid surface he should lower the pump in order to allow it to receive liquid for the full stroke.

Frequently in wells where the quantity of gas produced by the well is relatively small, an increased production of the pump may be obtained by raising the pump to a point nearer the liquid surface so that a better separation of the gas takes place prior to the entry of the liquid into the pump, while if the well

Defendant's Exhibit R—(Continued)

is making a large quantity of gas, it may be better to lower the pump to a point below where the gas is separated from the liquid so that upon each stroke of the pump, dense fluid will be picked up. However, in many instances, it is dangerous to lower the pump too close to the bottom as sand is likely to be pumped into and foul the pump.

In wells where the fluid level is so low that the pump is not completely submerged and hence does not receive a full cylinder or barrel of fluid upon each stroke, a pounding at the pump is created which may be heard or determined at the ground surface. This same character of pounding, however, may be produced by the pump even though the liquid surface is at a considerable distance above the pump inlet, occasioned by the inflow into the pump of large quantities of free gas. Hence, simple tests to determine the fluid level relative to the pump inlet will not produce the desired information to the operator as to the desirable character or location of the pumping mechanism.

If, however, the fluid pressure at different levels below the surface of the fluid is determined, this information may be employed to determine the most desirable location of the pump and whether or not a change should be made in the size, operating characteristics or character of the pumping equipment employed in a given well to produce an increased or maximum production from the well.

The determination of the fluid pressure at different points below the surface of the well may be deter-

Defendant's Exhibit R—(Continued)

mined by instruments known as pressure recorders, which must be either attached to the pump or lowered into the well to the desired level, or must be lowered into the well on wires, cables or other supporting devices and left at the desired levels for a predetermined length of time necessary to permit the recorders to make a chart or record of the pressures encountered. All of these methods, however, require the stopping of the pumps and the stopping of production while the test is being made and further require the removal of the pumps and sucker rods and sometimes the tubing and other apparatus from the well in order to insert the pressure recorders or pressure measuring devices, which entails considerable labor and time and holds up the production of the well for a considerable period of time.

It is therefore an object of my invention to provide methods for determining the fluid pressure at any given point below the surface of the standing column of liquid in the well, determining the density of the liquid in such column and the production index of the well without interrupting or interfering with the production of the well by the usual pumping apparatus employed therein.

Another object of my invention is to provide a ready means for determining the fluid pressure at any level below the surface of the standing column of liquid in the well and for determining the density of the liquid in any particular well without necessitating the removal or replacement of any of the usual pumping apparatus, flow tubes, sucker rods

Defendant's Exhibit R—(Continued)

or other mechanism found in a well being produced by a mechanical pump.

Another object of my invention is to provide information to aid in the determining of the proper location of a pump in an oil well to achieve the maximum volumetric efficiency of the pump in handling the particular character of fluid found in the particular well.

Another object of my invention is to provide a ready method for determining the potential production capacity of an oil well with a minimum of expense, delay or interruption of the production activities of the well.

Another object of my invention is to provide a method of determining the density of the fluid in a well by measuring the amount of recession of the level of the liquid surface under two conditions of pressure upon the liquid surface and computing from the facts thus obtained the density of the fluid in the well. Fluid densities in producing wells range all the way from less than .04 pounds per square inch to over .4 pounds per square inch per 100 feet of fluid in the well. Therefore, a simple fluid level determination without a density or pressure determination gives very little information.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by measuring the pressure at the pump inlet under two conditions of operation of the pump and computing therefrom the

Defendant's Exhibit R—(Continued)

maximum potential production obtainable from the well.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by determining the liquid pressure at some point below the liquid surface in the well, either at the pump inlet or any other location, under two conditions of production from the well (one of which may be zero production), and by comparing the pressures so determined with the production rates, determining the maximum potential production obtainable from the well.

Other objects of my invention will be apparent from a study of the following specification read in connection with the accompanying drawing, wherein

Fig. 1 is a diagrammatic, cross-sectional view of a typical oil well, illustrating the level of the liquid surface as being located a considerable distance above the inlet of the pumping apparatus employed.

Fig. 2 is a view similar to Fig. 1 but illustrating the effect on the liquid surface of gas pressure allowed to build up in the casing.

Fig. 3 is a diagrammatic view illustrating a chart or graph which may be employed in the practice of my method for the computation of fluid density and pressures at different locations or levels within the well;

Fig. 4 is a diagrammatic view illustrating a chart or graph which may be employed to compute the

Defendant's Exhibit R—(Continued)

maximum potential capacity of a well from a comparison of the pressure at the pump while it is idle with the pressure at the pump while it is operating normally; and

Fig. 5 is a view similar to Fig. 4 illustrating the manner in which a more accurate computation of the potential capacity of a well may be obtained by comparing the pressure at the pump under two production rates of the pumping apparatus.

Referring to the drawings, I have illustrated in Fig. 1 a typical oil well which includes a casing 1 extending down through the well bore from the ground surface 2 into the oil producing sands, the oil flowing from the sands or oil formation into the casing and rising in the casing to some level indicated at 3. Pumping apparatus employed to remove the oil from the well usually includes a suitable pump 4 located upon tubing string 5, constituting the flow tubing through which the oil is raised to the ground surface, the pump 4 including usually some reciprocating mechanism operated by reciprocal movements of a string of sucker rods 6 extending down through the tubing 5 and connected to reciprocating power apparatus at the ground surface, as indicated at 7. The flow tubing 5 is provided with an outlet 8 communicating with a suitable oil line through which the oil pumped from the well is conveyed to any desired location.

The casing 1 is closed at its upper end as indicated at 9, an outlet 10 being provided com-

Defendant's Exhibit R—(Continued)

municating with the casing 1 to permit gas escaping from the oil to pass into a suitable gas line 11, a control valve 12 being usually provided to control the flow of gas into the gas line.

By properly selecting the size, the stroke and the speed of the pump 4, the pump may be made to remove the oil from the well at approximately the same rate at which the oil flows into the well from the surrounding formation, and if so selected, the well will be operated at its maximum capacity. However, oil coming from the formation contains relatively large quantities of gas which, due to the pressure of the oil, cannot readily escape but which when the oil enters the pump tends to expand in the pump, reducing the volumetric efficiency of the pump. If now the pump is so located relative to the liquid surface that the greater portion of the gas within the well has been permitted to escape prior to the entry of the oil into the pump, it follows that upon each strike of the pump, the pump will be operated upon relatively dense fluid and will hence operate at relatively high volumetric efficiency.

I have discovered that a ready means for determining not only the pressure existing at the pump without requiring the removal of the pump or any of its apparatus but also I have discovered a ready method for determining the density of the fluid at the pump entrance, the information so obtained being used in the location of the pump at the most

Defendant's Exhibit R—(Continued)

desirable level to obtain the maximum volumetric efficiency of the pump.

To obtain the information required, I measure or determine the stable location of the liquid surface of the "standing column" of liquid within the well when the pump is operating at its normal production capacity and with the pressure of gas within the casing at the usual or normal value maintained during the usual or normal pumping operations at the well. The expression "standing column" as used herein is intended to mean the column of liquid which stands in the well as distinguished from the pumped liquid column which is being lifted to the ground surface by the pump, such standing column being known in the oil industry as the "dead" liquid column and with the usual type of pumping apparatus this standing column lies in the annular space between the tubing 5 and the casing 1. This location of the fluid level may be readily accomplished by employing the methods and apparatus disclosed in United States Letters Patent No. 2,047,974, issued to Harold T. Wyatt and Paul E. Lehr, July 21, 1936, and in my copending applications Serial No. 162,699, filed September 7, 1937, and Serial No. 164,534, filed September 18, 1937. While the methods and apparatus are completely disclosed in the said patent and applications, the method may be stated briefly as including the introduction into the annular space between the tubing 5 and the well casing of a sudden change in pressure in the well casing and meas-

Defendant's Exhibit R—(Continued)

uring the length of time elapsing between the production of this pressure impulse and the return to the ground surface of the echo thereof from the surface of the fluid. By noting the distance from the ground surface of the fluid level under these conditions and by noting the pressure of gas at the casing head, as by means of a pressure gauge 13, the pressure on the liquid surface may be computed as follows: to the casing head pressure is added the effect of pressure on the liquid surface exerted by the weight of the column of gas between the liquid surface and the casing head. A gravity test may be made of the gas at the casing head which will determine the pressure exerted by each foot or hundred feet of height of the gas column. This information may be computed by the following formula which is by Dice:

$$\text{Log}_{10}\text{Pb} = \frac{\text{SD}}{1.22.82\text{T}} + \text{Log}_{10}\text{Pt}$$

Where

Pb. = Lbs/sq. in. absolute at bottom of gas column.

Pt. = Lbs/sq. in absolute at top of gas column.

S = Specific gravity of the gas (air is considered 1).

D = Dept from casing head to liquid surface.

T = Mean temp. of the gas column in degrees F absolute.

This information may then be plotted upon a graph or chart illustrated in Fig. 3 in which the

Defendant's Exhibit R—(Continued)

conditions existing in the particular well under measurement are assumed to be such that with a pressure of 36 pounds per square inch at the casing head, the liquid surface is found to lie at 3100 feet below the casing head. The specific gravity of the gas in this instance may be found to be such that the effect will be to produce 4 pounds per square inch pressure on the liquid surface. Thus, the addition of 36 pounds and 4 pounds produces a total pressure on the liquid surface of 40 pounds per square inch. By arranging the chart shown in Fig. 3 with the ordinates representing the fluid level measured from the ground surface and the abscissae representing the pressure on the liquid surface in pounds per square inch, the point L1 determined from the preceding formula may be plotted on the chart shown in Fig. 3.

Now, the valve 12 is closed or a suitable pressure regulator is placed in the gas line 11 and the pressure within the casing is allowed to build up to any predetermined value. As the pressure builds up, the oil level 3 tends to recede. By continuing the operations of the pump during the building up of this pressure, preferably for a period substantially equal to three times the length of time required for the pump to remove the column of fluid between the original fluid level and a new fluid level to which the pressure depresses the liquid surface, represented at 3a (Fig. 2), it will be found that a stable condition will be achieved at which the fluid level will become constant and

Defendant's Exhibit R—(Continued)

the production by the pump will be approximately the same as before the pressure was allowed to build up in the casing. When this stable condition is reached, a second measurement of the fluid level is obtained by the level measuring methods and apparatus hereinbefore described.

Having determined the new location of the liquid surface, the pressure exerted thereon may now be calculated as follows: Assuming that the casing head pressure in this instance was adjusted to 170 pounds, to this should be added the pressure due to the weight of the column of gas above the new fluid level. The determination of the effect of the weight of the column of gas upon the fluid level may be obtained either by calculation or may be plotted out and obtained from suitable charts prepared for this purpose. In this instance, it may be assumed that the pressure due to the gas column is 30 pounds per square inch, making a total of 200 pounds per square inch on the fluid. Now, assuming that the level to which the standing column of liquid mixture of oil and gas has receded as 3966 feet from the top of the well, the new point L2 on the chart shown in Fig. 3 representing the new level and the pressure on the liquid surface may be placed upon the chart. From an exhaustive series of actual tests, it has been discovered that the relation between the pressure on the liquid surface and the distance through which the fluid will recede in any given well having a uniform cross sectional area is constant, so that a line drawn on the

Defendant's Exhibit R—(Continued)

chart shown in Fig. 3 intersecting the points L1 and L2 will truly represent the fluid level at any of the pressures which may be placed upon the fluid column. Thus, by merely extending the line C downwardly on the chart until it crosses the ordinate representing the location of the pump inlet indicated on the chart as A, a direct reading of the fluid pressure required to cause the surface of the column to recede to the pump inlet is obtained. On the chart this is represented as 336 pounds per square inch, which is the pressure at the pump for the normal rate of production, assuming that the rate of production was normal during the tests.

The actual pressure in the column of liquid at the pump inlet may, however, be calculated from the information received by the two fluid level tests described above. That is, by subtracting the original fluid level from the new fluid level, the total difference in level will be found, in this instance 866 feet. Then, by subtracting the original pressure on the liquid surface from the new pressure on the liquid surface, a difference of 160 pounds per square inch is found to have been necessary to cause the liquid column to recede 866 feet. By dividing the difference in fluid pressure by the difference in surface level, the density of the liquid mixture of oil and gas in the well (that is, the pressure exerted by this mixture per unit of height of the column of liquid mixture) may be found. In this instance, the column receded a distance be-

Defendant's Exhibit R—(Continued)

tween 3100 feet and 3966 feet or a total distance of 866 feet, while the pressure difference is 160 pounds. The density of the liquid is such therefore as to exert 0.185 pounds per square inch per foot of height of the column.

Hence, knowing the pressure on the fluid surface at any level thereof and knowing the distance below this surface at which the pump inlet is located, a direct calculation of the fluid pressure at the pump inlet may be obtained by the following formulae:

The pressure at any point below the normal fluid level in a well at which the level can be maintained by means of gas pressure in the casing is

$PL1 = Pc1 + Pg1$ and $PL2 = Pc2 + Pg2$

The density of the fluid for the rate of production during the tests is

$$D = \frac{PL2 - PL1}{L2 - L1} = \text{density of the fluid in lbs. per sq. in. per ft. of fluid.}$$

The pressure at the pump is

$$Pa = D(La - L2) + PL2$$

Where

Pc1 = gage casing pressure to maintain fluid at level L1.

Pc2 = gage casing pressure to maintain fluid at level L2.

Pg1 = pressure exerted upon fluid surface by weight of gas above it at level L1.

Pg2 = ditto for level L2.

PL1 = pressure on the fluid surface at level L1.

Defendant's Exhibit R—(Continued)

PL2 = pressure on the fluid surface at level L2.

L1 = fluid level corresponding to Pcl.

L2 = fluid level corresponding to Pc2.

La = pump location in feet from ground surface.

Pa = pressure at the pump.

In the example shown in Fig. 3, assuming the inlet to the pump is located at the 4700 foot level, the pressure of the oil at this point would be equal the sum of the gas pressure at the casing head for level L2, the pressure exerted by the column of gas above the liquid surface corresponding to this level and the pressure exerted by the column of oil above the pump inlet. In this instance, the pressure at the casing head is assumed to be 170 pounds per square inch, the effect of the column of gas at this pressure with the fluid level at 3966 feet from the surface being 30 pounds per square inch and the effect of the column of liquid above the pump inlet being 734 feet at the .185 pounds per square inch per foot, or 135.5 pounds per square inch exerted by the column of liquid, the result being 335.5 pounds per square inch pressure at the pump entrance. This result is clearly illustrated in Fig. 3 by the point A, the point A being located at the 335.5 pounds mark on the abscissae of the chart. If desired, an estimation of the bottom hole pressure may also be made by continuing the line C downwardly on the chart to intersect the ordinate representing the bottom of the well, such point being indicated at B, or the pressure at any other level in the well below the surface of

Defendant's Exhibit R—(Continued)

the liquid for the rate of production at which the tests were made may be located along the line C. I have discovered that in wells employing mechanical pumps for any given production rate by the pump, the density of the oil and gas mixture is constant throughout the height of the standing column of liquid in the annular space between the tubing and casing so that the line C once established continues as a straight line, the effect in pressure per unit of height of the column being constant throughout the height of the column.

Knowing the density of the oil and the pressure exerted at the pump inlet, the operator of any particular well may determine whether or not it is practicable to increase the amount of fluid being produced. If the volumetric efficiency of the pump is low and the tests indicate considerable pressure at the pump, he may raise the pump to a level indicated upon the line C at which better separation of gas will usually occur prior to entry of fluid into the pump.

The utilization of the information obtained by the foregoing method will also accurately produce the information of the maximum potential production of the well as by comparing the pressure of the fluid at the pump under two or more different operating conditions of the pump. For example, the static fluid pressure at the pump when the pump is not operating may be measured and compared with the fluid pressure at the pump when

Defendant's Exhibit R—(Continued)

the pump is operating at its normal rate of production, a comparison of the two values so obtained will produce a constant, indicating the ratio between the rates of production and pressure at the pump inlet, so that by employing this constant at a theoretical zero pump inlet pressure (which would represent the fluid being removed from the well at the rate it flows into the well from the formation) the maximum potential capacity of the well may be found.

Employing the method of determining fluid pressure at the pump hereinbefore described, the static liquid pressure may be readily obtained without necessitating the use of pressure recorders or other devices requiring the removal of or alteration of any of the pumping mechanism and the measurement may be made in wells which have been shut down as readily as in wells which are actively producing.

To obtain the fluid pressure at any point at or below the liquid surface when the well is not producing fluid, the casing should be closed in and the gas escaping from the liquid should be allowed to build up pressure in the casing until a suitable condition is reached, that is, a point is reached at which no more gas is made by the well (no more gas escapes from the liquid). When this point is reached, the remaining fluid in the well may be considered as dense fluid.

Now, by determining the height of the liquid surface under these conditions by my method, the

Defendant's Exhibit R—(Continued)

pressure on the liquid surface may be readily determined and by adding thereto the effect of the weight of the column of fluid above any given level, the fluid pressure at that level may be found. This information alone is extremely useful to the operators of producing wells.

The information thus obtained may be plotted on a graph or chart such as that shown in Fig. 4, wherein the ordinates represent fluid pressure at the pump inlet in pounds per square inch and the abscissae represent rate of production of oil from the particular well under consideration, and the static pressure may be plotted at zero production, as indicated by the point D in Fig. 4.

The casing pressure may now be reduced and the pump started and allowed to assume a predetermined rate of production, preferably its normal rate. Assuming this rate is 200 barrels of oil per day, a new determination of the fluid pressure at the pump is made at this rate of production. That is, the pump is started and allowed to operate until the fluid level in the well reaches a stable condition. The location of the fluid level and the pressure in pounds per square inch at the pump inlet under these conditions are determined by the method hereinbefore described and the fluid pressure at the pump is plotted against the production rate on the chart shown in Fig. 4. Assuming that this new pressure at 200 barrels per day is found to be at the point indicated in Fig. 4 at E, a straight line drawn between the points D

Defendant's Exhibit R—(Continued)

and E will intersect the zero pressure ordinate at a point representing the maximum potential capacity of the well. In the diagram shown in Fig. 4, this maximum potential production capacity is found to be 300 barrels per day. In other words, if a pump of sufficient capacity is installed in this well and operated in such manner as to remove 300 barrels per day, the oil will be removed at the same rate at which it flows from the well from the formation.

A more accurate determination of the maximum potential production capacity of the well may be made by comparing the fluid pressure at the pump under two different operating conditions of the pump, such as by measuring the fluid pressure at the pump when the pump is operating at one production rate, for example its normal rate, and then changing the rate of production of the pump as by slowing the pump down or changing the stroke of the pump and plotting the relation between the new production rate and the fluid pressure measured by my method, as set forth herein, it will be found that a line intersecting these two points will also represent the relation between production rate and fluid pressure at the pump at any rate of production by the pump. As shown in Fig. 5, the normal production rate of 200 barrels per day plotted against the fluid pressure at the pump in pounds per square inch may be represented upon the chart by the point G while at a reduced rate of

Defendant's Exhibit R—(Continued)

production at the pump, say to 100 barrels per day, it will be found that the fluid pressure at the pump is increased so that by determining the fluid pressure under these conditions, the relation between the reduced production rate and the fluid pressure at the pump may be plotted by the point H. A straight line interconnecting the points H and G will intersect the zero pressure ordinate at a point therealong, indicating a maximum possible production of 300 barrels per day. In making such determinations, however, it is desirable that the rate of production of the pump be reduced to at least two thirds of its normal production rate and preferably to 50% of its normal production rate in order to obtain substantially widely separated points H and G.

Again, it will be noted that all of the necessary calculations to determine the maximum production possible of the well may be made without interrupting the normal production conditions at the well and without requiring the laborious efforts of removing and replacing any of the pump mechanisms.

It will therefore be observed that I have provided a ready method for determining the density of the fluid in any particular well and also for the determination of the fluid pressure at the pump without requiring the removal or alteration of any of the usual mechanism found in the well. It will also be noted that I have provided a ready method for graphically determining the fluid pres-

Defendant's Exhibit R—(Continued)

sure at the pump by first determining the amount of recession of the fluid level due to changes in gas pressure exerted upon the fluid surface and plotting this information upon a graph or chart and extending a straight line intersecting the two or more points so located to a point on the chart representing the level of the pump inlet. It will also be noted that I have devised a ready means of utilizing the information obtained with respect to fluid levels and gas pressures at the casing head for mathematically determining the fluid pressure at the pump and also for utilizing this information to determine accurately the potential production of any well measured. It should also be noted that all of the measurements necessary to provide for the computations and calculations explained herein may be accomplished without interrupting the operation of the pump except for the measurement of the static pressure as described herein.

While I have illustrated and described the preferred embodiment of my invention, I do not desire to be limited to any of the detail illustrated or described herein, except as defined in the appended claims.

WM:MM

I CLAIM:

1. The method of determining the density of the standing column of liquid in a well, which comprises measuring the stable level of the liquid column under one condition of gas pressure, changing the pressure of gas within the well to move the

Defendant's Exhibit R—(Continued)

surface of the liquid to a new stable level, measuring the new stable level and dividing the change in pressure on the liquid surface required to achieve the new level by the difference in height between the two levels.

2. The method of determining the density of liquid in a well having a casing and a pump suspended therein on tubing and without requiring removal of pump parts, which consists in determining the liquid level in the annular space between the pump tubing and the casing under one condition of pressure, changing the pressure of the gas within the well to move the liquid surface to a new stable level, measuring the new level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference between the two levels.

3. The method of determining the density of the standing column of liquid in a well having a casing and a pump suspended therein, which consists in measuring the level of the standing column of liquid in the well while the pump therein is operated at a given rate of production and under a known condition of gas pressure on the surface of the liquid column, changing the gas pressure on the liquid column, continuing the operation of the pump at the same production rate until the level of the standing column becomes stable at a new location, measuring the new level and comparing the difference in the pressures exerted on the liquid

Defendant's Exhibit R—(Continued)

surface at the two levels with the difference in height of the two levels.

4. The method of determining the density of the standing column of liquid in a well having a casing and a pump suspended therein, which consists in measuring the stable level of the surface of the standing column of liquid under one condition of pressure of gas released by the well, measuring the pressure on said liquid surface under said one condition of gas pressure, regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level, measuring the new level, measuring the pressure on the liquid surface at the new level, and comparing the difference in the pressures exerted upon the liquid surface under the two conditions of gas pressure with the difference in height of the levels of the liquid surface under the two pressure conditions.

5. The method of determining the density of the standing column of liquid in an oil well having a casing and a mechanical pump suspended therein upon pump tubing and without requiring the removal of pump parts which consists in the steps of operating the pump under one stable condition of gas pressure in the casing until the liquid level becomes stable, measuring the distances between the casing head and the surface of the liquid under this stable condition, altering the casing pressure to a new condition, operating the pump at the same rate of production under the new condition of gas

Defendant's Exhibit R—(Continued)

pressure to again stabilize the liquid level, measuring the distance between the casing head and the new level of the liquid surface under said new stable condition, and measuring the casing head pressures under the two stable conditions, whereby the pressure exerted by the liquid per unit of height of the liquid is represented by comparing the difference in height of the liquid surface levels and the difference between the pressures on the liquid surface required to maintain the liquid surface at the two levels.

6. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of liquid in the well at any desired level below the normal surface of said column and without requiring the removal of any of the pump parts, which comprises measuring the actual stable level of the liquid column under one known condition of gas pressure in the casing, determining the pressure on the liquid surface at that level, changing the pressure of gas in the well to move the surface of said column to a new actual stable level, measuring the new level of the liquid surface, determining the pressure on the liquid surface at the new level, determining the density of the liquid by dividing the change in pressure on the liquid surface required to achieve the new level by the differnce in height of the two levels and computing the unknown pressure at the desired level by adding to the pressure on the liquid surface at either of the

Defendant's Exhibit R—(Continued)

levels the effect in pressure of the column of liquid of the density so determined between the selected actual level and the desired level.

7. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted by the standing column of liquid at any desired level below the normal surface of said column while the pump is operating to remove liquid from the well, which comprises measuring the actual stable level of the liquid under one known condition of gas pressure in the well by sonic sounding method, determining the pressure on the liquid surface at that level, changing the pressure of the gas in the well to move the surface of the column to a new actual level, continuing to operate the pump at the same production rate as for the first condition of gas pressure in the well until the liquid level again becomes stable, measuring the new stable level and determining the pressure upon the liquid surface at this new level, determining the pressure exerted per unit of height of the liquid column by dividing the change in gas pressure on the liquid surface required to effect the change in the liquid level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the gas pressure upon the liquid surface at either of the actual levels the effect in pressure of the liquid column between the selected actual level and the desired level.

8. The method of determining the potential pro-

Defendant's Exhibit R—(Continued)

duction capacity of a well having a casing and a pump suspended therein, which comprises measuring the stable level of the surface of the standing column of liquid in the well at one known rate of production and under one known condition of gas pressure in the well, determining the pressure on the surface of the liquid column at that level, changing the gas pressure in the well to move the surface of the liquid column to a new stable level, measuring the level of the liquid surface under the new gas pressure condition and determining the pressure on the liquid surface at the new level, dividing the change in pressure on the liquid surface by the difference in height between the two levels to thereby determine the density of the liquid in the column at that rate of production, determining the pressure at some predetermined desired point below the normal liquid surface for that rate of production by adding to the pressure on the liquid surface for either of the measured levels the effect in pressure of the column of liquid between that level and the predetermined desired point, then changing the rate of production by the pump and repeating the liquid level change and gas pressure determinations to determine the density of the liquid in the column and the pressure of the liquid at the said predetermined desired point for the new rate of production and then dividing the difference in the two production rates by the difference in the corresponding liquid pressures at the desired point and using the ratio thus

Defendant's Exhibit R—(Continued)

found to determine the maximum rate at which the well is capable of being produced.

In testimony whereof I affix my signature

CRANFORD P. WALKER.

OATH

State of California
County of Los Angeles—ss.

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of San Marino, in the County of Los Angeles, State of California, that he verily believes himself to be the original, first and sole inventor or discoverer of the Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, described and claimed in the annexed specifications; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to the filing of his parent application for United States Letters Patent, Serial No. 171,170 of which this application is a continuation, or in public use or on sale in the United States for more than two years prior to the said parent application; that said invention has not been patented in any country foreign to the United States on any application filed by him or his legal representatives or assigns more than twelve months

Defendant's Exhibit R—(Continued)

prior to this application; and that no application for patent on said invention has been filed by him or his legal representatives or assigns in any country foreign to the United States.

CRANFORD P. WALKER

Subscribed and sworn to before me, this 14th day of April, 1939.

[Seal] MARJORIE McKAY

Notary Public in and for the County of Los Angeles, State of California.

My Commission Expires July 14, 1941.

Defendant's Exhibit R—(Continued)
Div. 36 Room 7892
Buchler:mwc
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
Paper No. 3
All communications respecting this
application should give the serial number
date of filing, and name of
the applicant
254
Department of Commerce
United States Patent Office
Washington

Mailed Apr 28 1939

Please find below a communication from the Examiner in charge of this application

CONWAY P. COE
Commissioner of Patents.

Harold W. Mattingly,
720 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

Ser. No. 268805
Filed Apr. 19, 1939
For Method of Determining Fluid Density,
Fluid Pressure and the Production
Capacity of Oil Wells

In accordance with the provisions of Order

Defendant's Exhibit R—(Continued)

No. 2308, dated March 12, 1917, which reads in part as follows:

* * * * * *

> Obvious informalities in the application may be corrected by the examiner, but said correction must be in the form of an amendment, approved by the Principal Examiner in writing, placed in the file, and made a part of the record. The changes specified in the amendment will be entered by the clerk in the regular way.

* * * *

the changes, hereinafter specified, are made by the examiner in the application above identified.

Should these changes not be satisfactory to the applicant, appropriate amendment may be proposed under the provisions of Rule 78, provided the specification has not been printed.

The application has been amended as follows:

In Fig. 4, Pump has been substituted for "Top".

Corrected. M. B. Div. 36. April 27, 1939.

A. D. McFADYEN

Examiner.

401

Div. 36.

TITLE REPORT

No. 268,805, Continuation of Ser. No. 171,170.

Name Cranford P. Walker.

Defendant's Exhibit R—(Continued)

The title appears from the assignment records to be vested in:

The Inventor.

Examined up to and including Apr. 18, 1939.

This certificate dated May 3, 1939.

H. C. SPIELMAN

Asst. Chief of Assignment Division.

No further assignments appear to have been received for record including Apr. 29, 1939.

Address only

The Commissioner of Patents

Washington, D. C.

Serial No. 268805

Mailed May 8 1939.

Div. 36 - Rm 7892 - mwc

Department of Commerce

United States Patent Office

Washington

May eighth, 1939

Cranford P. Walker,

Your Application for a patent for an Improvement in Method of Determining Fluid Density Fluid Pressure and the Production Capacity of Oil Wells filed Apr. 19, 1939 has been examined and Allowed with 8 claims.

The final fee, Thirty Dollars, With $1 Additional for Each Claim Allowed in Excess of 20, must be

Defendant's Exhibit R—(Continued)

paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld, but the application may be renewed within one year after the date of the original notice, with a renewal fee of $30 and $1 additional for each claim in excess of 20.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, Distinctly and Plainly Written, the name of the Inventor, Title of the Invention, and Serial Number as Above Given, Date of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names of the Assignees.

If it is desired to have the patent issue to an Assignee or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than

Defendant's Exhibit R—(Continued)

the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Notice.—When the number of claims allowed is in excess of 20, no sum less than $30 plus $1 additional for each claim in excess of twenty can be accepted as the final fee.

Respectfully,

CONWAY P. COE

Commissioner of Patents.

Harold W. Mattingly,
720 Pacific Finance Bldg.,
621 S. Hope Street,
Los Angeles, California.

[Printed in margin]: In Remitting the Final Fee Give The Serial Number at the Head of this Notice.

[Printed in margin]: Uncertified Checks Will Not Be Accepted.

Defendant's Exhibit R—(Continued)

May-11-39 229438 D — Check — 30.00.

327

FINAL FEE PAID TO THE COMMISSIONER OF PATENTS

(Be careful to give correct Serial No.)

Mail Division May 11 1939 U. S. Patent Office.

Serial No. 268805

Inventor:

Cranford P. Walker

Patent To Be Issued To

Inventor.

Name Of Invention, As Allowed:

Date Of Payment:

May 11 1939

Fee:

$30

Date Of Filing:

Apr 20 1939

Date Of Circular Of Allowance:

May 8 1939

The Commissioner of Patents will please apply the accompanying fee as indicated above.

H. W. MATTINGLY

Attorney.

Send Patent To

H. W. Mattingly

621 So. Hope St.

Los Angeles, Calif.

Defendant's Exhibit R—(Continued)

Final fees will not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office, Nor Will They Be Applied In Pending Applications.

[Printer's Note: Copy of Patent No. 2,161,733 issued to C. P. Walker entitled Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells attached here is not reproduced, as it is set out in full as Defendant's Exhibit O-1 in this printed record.]

22-76

Patent No. 2161733

Inventor C. P. Walker

An application for reissue

of this patent was filed on Dec 4, 1939.

Reissue application abandoned on.....

Reissue Patent issued on March 5, 1940.

As Reissue No. 21,383.

Do Not removed this from file.

13 Oil Well

June 6, 1939. C. P. WALKER 2,161,735

METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND THE PRODUCTION CAPACITY OF OIL WELLS

Original Filed Oct. 28, 1937

O.G. 816 CLASS 73 SUB CLASS 51

Fig. 1.

Fig. 2.

Fig. 3.

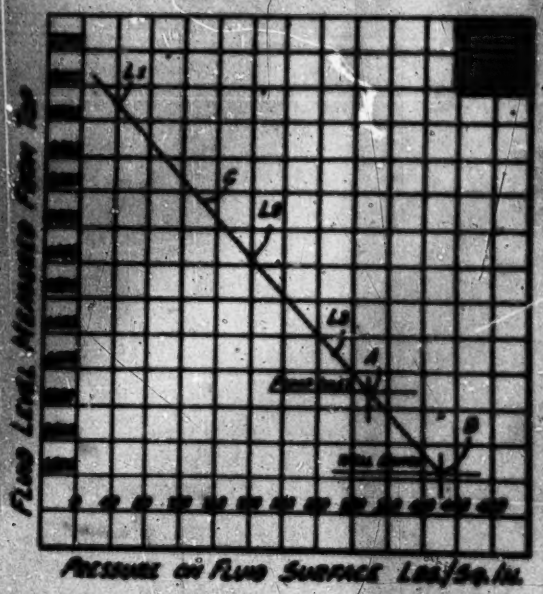


Fig. 4.

Fig. 5.

INVENTOR.
CRAWFORD P. WALKER

BY

ATTORNEY.

Defendant's Exhibit R—(Continued)

District Court of the United States
Southern District of California—Central Division

Honorable Commissioner of Patents,
Washington, D. C.

Sir:

In compliance with the Act of February 18, 1922 (42 Stat. L. 392), you are advised that there was filed on the 16th day of July, 1941, in this court an action, suit, or proceeding No. 1655-H-Civ., entitled:

Name Cranford P. Walker, etc., et al., Plaintiffs,
Address Los Angeles, California,

versus

Name Halliburton Oil Well Cementing Co., a Delaware corp., Defendant,

Address Los Angeles, California.

brought upon the following patents:

	Patent No.	Date of Patent	Patentee
1.	2,156,519	May 2, 1939	Cranford P. Walker
2.	2,161,733	June 6, 1939	Cranford P. Walker
3.	Reissue 21,383	Mar. 5, 1940	Cranford P. Walker

In the above-entitled case the following decision has been rendered or decree issued:

.....

In Witness Whereof I have affixed my hand this 16th day of July, 1941, at Los Angeles, Calif.

R. S. ZIMMERMAN,
Clerk of said Court.
By L. WAYNE THOMAS
L. Wayne Thomas,
Deputy Clerk.

Defendant's Exhibit R—(Continued)

421

1939

Contents

1. Application.....papers.
2. Print 4-24-39
3. Exrs Amdt A Apr-28-39
4. Appln for Reissue Dec 4, 1939
5. Notice of suit July 21-1941

[Endorsed]: Filed Nov. 9, 1942.

DEFENDANT'S EXHIBIT S

390

Department Of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents, in the matter of the

Reissue Letters Patent of
Cranford P. Walker,

Number 21,383, Granted March 5, 1940,

for

Improvement in Methods of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be

Defendant's Exhibit S—(Continued)

affixed at the City of Washington, this seventh day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

Attest:

[Seal] D. E. WILSON
Chief of Division.

CONWAY P. COE
Commissioner of Patents.

PATENTED FILE

RETURN TO RECORD ROOM

13682

NUMBER (Series of 1935)

307551

REISSUE NO. 21,387

DIV. 36

1939 DATED

(EX'R'S Book)

Name CRANFORD P. WALKER

of SAN MARINO

State of CALIFORNIA

Invention METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE AND THE PRODUCTION CAPACITY OF OIL WELLS

APPLICATION FILED COMPLETE, DEC 4 1939

PARTS OF APPLICATION FILED

Petition, Specification, Oath, Fee $30, Old Patent, Abstract of Title, 1 Sheets Drawings, ORDERED DEC 4 1939

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By Commissioner

Attorney HAROLD W. MATTINGLY 621 S. HOPE ST LOS ANGELES CALIF.

Associate Attorney

Number of Claims Allowed 11-First Class

Title as Allowed Method of determining fluid density, fluid pressure and the production capacity of oil wells.

Commissioner of Patents
Division of Original Patents No. 174,170 Filed October 26, 1937

Defendant's Exhibit S—(Continued)

Walter P. Huntley MAdison 1137
Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
621 South Hope Street
Los Angeles, California

November 29, 1939.

Dec-4 39 185830 B — Check — 30.00

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Attached is application for Letters Patent of the United States (Reissue), executed November 15, 1939 for Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells by Cranford P. Walker; also attached is my check No. 1556 in the amount of $30.00 to cover the Government filing fee (11 claims).

Also attached is original United States Letters Patent No. 2,161,733 offered for surrender.

For drawings in connection with this application, it is requested that the Patent Office transfer the original drawings from application Serial No. 268,805, of which this is a reissue, and it is further requested that photostatic prints of the said drawings be furnished for application Serial No. 268,805, the cost of which may be charged to my miscellaneous fees account.

Respectfully,

HAROLD W. MATTINGLY.

[Longhand Note]: orig. pat. herewith.

Defendant's Exhibit S—(Continued)

In The United States Patent Office

Re: United States Letters Patent No. 2,161,733

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and The Production Capacity of Oil Wells

Issued: June 6, 1939

Application Filed: October 26, 1937 (Serial No. 171, 170 and 268,805.

PETITION FOR REISSUE

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Your petitioner Cranford P. Walker, a citizen of the United States, and a resident of San Marino, in the County of Los Angeles, State of California, whose post office address is 2824 Carlaris Road, San Marino, California, prays that he may be allowed to surrender the Letters Patent for an improvement in Method of Determinating Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells No. 2,161,733, granted to him on June 6, 1939, and that Letters Patent may be issued to petitioner for the same invention upon the annexed amended specification.

With this petition is filed an order for making and filing a certified abstract of title as required in such cases.

My invention relates to methods of determining

Defendant's Exhibit S—(Continued)

the fluid density, fluid pressure and potential production capacity of oil wells and has particular reference to methods of determining the most desirable character of pumping equipment and manner of operating the same to permit an effieient production of oil from a given well.

This application is a continuation of my copending application Serial No. 171,170, filed October 26, 1937.

It is the common practice in oil well production activity to permit an oil well to produce as a flowing well, that is, to permit the oil to flow out at the ground surface due to the pressure in the oil formations, until the production rate reaches a considerably low value or ceases, after which gas lifting is usually attempted and continued until the production rate with gas lifting reaches a relatively low value or the production entirely ceases. At this time, and in some instances prior to any attempt to gas lift the oil, mechanical pumping devices are usually installed to lift the oil by mechanical means to the surface, these pumps usually comprising a pump barrel located at a considerable depth in the well, usually 50 to 150 feet below the surface of the well fluid in the well while it is producing, plungers or other reciprocating devices being employed in the barrel and operated from the ground surface by means of sucker rods.

Usually the selection of the size and character of the pumping equipment is determined by the production of the well during its flowing or gas lift-

Defendant's Exhibit S—(Continued.)

ing life by estimating from this production the type or character of pump which appears to be most suitable. In many fields, however, the type, size and character of the pump installed is usually one determined as "standard" for that particular type of well in the particular field. In other words, it is one having the same dimensions as pumps in other wells producing from the same horizon. Frequently, such well receives no further attention until the field as a whole has declined to a point where it becomes necessary to increase the production from the wells, as for example, by the encroachment of water, necessitating the lifting of greater quantities of liquid in order to obtain the desired amount of oil. When this condition occurs, it is customary to increase the capacity of the pumping equipment.

Also, the production from a given well may be believed to be less than the character of the well and the character of the pumping equipment employed should indicate, as for example, the pump may be operating at a relatively low volumetric efficiency. As is well understood, the column of well fluid extending up into the well bore is a mixture of dense oil and gas entrained therewith and the maximum volumetric efficiency of the conventional pumping equipment is attained when the pump inlet is located along this column at such place as will permit a maximum amount of dense liquid to flow into the pump upon each stroke. Thus if the

Defendant's Exhibit S—(Continued)

pressure in the column at any point below the surface of the column can be determined, the pump inlet may be so properly located as to allow it to take in a minimum quantity of gas upon each stroke. At this point it should be noted that wherever in the following description the expression "fluid", "fluid surface", "fluid level", are used, the word "fluid" is intended to refer to the natural well fluid which comprises a mechanical mixture of dense liquid, (either oil or oil and water) with such quantities of gas entrained therein as may be present in the particular well under consideration.

In order to determine whether or not any change in the size, character, operating characteristics or location of the pumping apparatus should be made, it is desirable that the location of the fluid surface, the character of the fluid in the well, its density and the fluid pressure exterted at any given point below the surface of the fluid and the maximum potential production capacity of the well should be determined. For example, if the pumps in a particular field are operating at good volumetric efficiency, much can be determined from the quantity of oil produced and the volumetric displacement per stroke of the pump, and if the pumps are operating at their maximum capacity, the fact that the fluid level is at a considerable distance above the pump inlet may indicate that the operator is justified in making a change in the size or character of the pumping equipment. Again,

Defendant's Exhibit S—(Continued)

if the volumetric efficiency of the pump is found to be low, as for example, when the pump appears to be taking in a comparatively large quantity of gas upon each stroke of the pump, the operator should know whether or not the inlet of the pump is located at a point too near the fluid surface so that he may determine how far below the fluid surface he should lower the pump in order to allow it to receive dense fluid for the full stroke.

Frequently in wells where the quantity of gas produced by the well is relatively small, an increased production of the pump may be obtained by raising the pump to a point nearer the fluid surface so that a better separation of the gas takes place prior to the entry of the fluid into the pump, while if the well is making a large quantity of gas, it may be better to lower the pump to a point below where free gas enters the well bore, if this is possible, so that upon each stroke of the pump, dense liquid will be picked up. However, in many instances, it is dangerous to lower the pump too close to the bottom as sand is likely to be pumped into and foul the pump.

In wells where the fluid level is so low that the pump is not completely submerged and hence does not receive a full cylinder, or barrel of fluid upon each stroke, a pounding at the pump is created which may be heard or determined at the ground surface. This same character of pounding, however, may be produced by the pump even though the fluid surface is at a considerable distance above

Defendant's Exhibit S—(Continued)

the pump inlet, occasioned by the inflow into the pump of large quantities of free gas. Hence, simple tests to determine the fluid level relative to the pump inlet will show which of these two conditions exists but will not produce the desired information to the operator as to the desirable character or location of the pumping mechanism.

If, however, the fluid pressure at different levels below the surface of the fluid is determined, this information may be employed to determine the most desirable location of the pump and whether or not a change should be made in the size, operating characteristics or character of the pumping equipment employed in a given well to produce an increased or maximum production from the well.

The determination of the fluid pressure at different points below the surface of the well fluid may be determined by instruments known as pressure recorders, which must be either attached to the pump or lowered into the well to the desired level, or must be lowered into the well on wires, cables or other supporting devices and left at the desired levels for a predetermined length of time necessary to permit the recorders to make a chart or record of the pressures encountered. All of these methods, however, required the stopping of the pumps and the stopping of production while the test is being made and further required the removal of the pumps and sucker rods and sometimes the tubing and other apparatus from the

Defendant's Exhibit S—(Continued)

well in order to insert the pressure recorders or pressure measuring devices, which entailed considerable labor and time and held up the production of the well for a considerable period of time.

It is therefore an object of my invention to provide methods for determining the fluid pressure at any given point below the surface of the column of well fluid which extends up into the space between the casing and the pump tubing (known as the 'standing column'), determining the density of the fluid in such column and the production index of the well without interrupting or interferring with the production of the well by the usual pumping apparatus employed therein.

Another object of my invention is to provide a ready means for determining the fluid pressure at any level below the surface of the standing column of fluid in the well and for determining the density of the well fluid in any particular well without necessitating the removal or replacement of any of the usual pumping apparatus, flow tubes, sucker rods or other mechanism found in a well being produced by a mechanical pump.

Another object of my invention is to provide information to aid in the determining of the proper location of the pump in an oil well to achieve the maximum volumetric efficiency of the pump in handling the particular c haracter of well fluid found in the particuar well.

Another object of my invention is to provide a ready method for determining the potential pro-

Defendant's Exhibit S—(Continued)

duction capacity of an oil well with a minimum of expense, delay or interruption of the production activities of the well.

Another object of my invention is to provide a method of determining the density of the fluid in a well by measuring the amount of recession of the level of the fluid surface under two or more conditions of pressure upon the fluid surface and computing from the facts thus obtained the density of the fluid in the well. Fluid densities in producing wells range all the way from less than .04 pound per square inch to over .4 pound per square inch per foot of fluid in the well. Therefore, a simple fluid level determination without a density or pressure determination gives very little information.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by measuring the pressure at the pump inlet under two conditions of operation of the pump and computing therefrom the maximum potential production obtainable from the well.

Another object of my invention is to provide a ready method for determining the potential production capacity of a well by determining the fluid pressure at some point below the fluid surface in the well, either at the pump inlet or any other location, under two conditions of production from the well (one of which may be zero production), and by

Defendant's Exhibit S—(Continued)

comparing the pressures so determined with the production rates, determining the maximum potential production obtainable from the well.

Other objects of my invention will be apparent from a study of the following specification read in connection with the accompanying drawing, wherein

Fig. 1 is a diagrammatic, cross-sectional view of a typical oil well, illustrating the level of the fluid surface as being located a considerable distance above the inlet of the pumping apparatus employed;

Fig. 2 is a view similar to Fig. 1 but illustrating the effect on the fluid surface of gas pressure allowed to build up in the casing;

Fig. 3 is a diagrammatic view illustrating a chart or graph which may be employed in the practice of my method for the computation of fluid density and pressures at different locations or levels within the well;

Fig. 4 is a diagrammatic view illustrating a chart or graph which may be employed to compute the maximum potential capacity of a well from a comparison of the pressure at the pump while it is idle with the pressure at the pump while it is operating normally; and

Fig. 5 is a view similar to Fig. 4 illustrating the manner in which a more accurate computation of the potential capacity of a well may be obtained by comparing the pressure at the pump under two production rates of the pumping apparatus.

Defendant's Exhibit S—(Continued)

Referring to the drawings, I have illustrated in Fig. 1 a typical oil well which includes a casing 1 extending down through the well bore from the ground surface 2 into the oil producing sands, the oil flowing from the sands or oil formation into the casing and rising in the casing to some level indicated at 3. Pumping apparatus employed to remove the oil from the well usually includes a suitable pump 4 located upon tubing string 5, constituting the flow tubing through which the oil is raised to the ground surface, the pump 4 including usually some reciprocating mechanism operated by reciprocal movements of a string of sucker rods 6 extending down through the tubing 5 and connected to reciprocating power apparatus at the ground surface, as indicated at 7. The flow tubing 5 is provided with an outlet 8 communicating with a suitable oil line through which the oil pumped from the well is conveyed to any desired location.

The casing 1 is closed at its upper end as indicated at 9, an outlet 10 being provided communicating with the casing 1 to permit gas escaping from the oil to pass into a suitable gas line 11, a control valve 12 being usually provided to control the flow of gas into the gas line.

By properly selecting the size, the stroke and the speed of the pump 4, the pump may be made to remove the oil from the well at approximately the same rate at which the oil flows into the well from the surrounding formation, and if so selected, the well will be operated at its maximum capacity.

Defendant's Exhibit S—(Continued)

However, oil coming from the formation contains relatively large quantities of gas which, due to the pressure of the oil, cannot readily escape and is drawn into the pump with the oil, thereby reducing the liquid volumetric efficiency of the pump.

I have discovered a ready means for ascertaining the pressure existing at the pump entrance or at any other point below the surface of the standing column of well fluid in any given well without requiring the removal of the pump or any of its parts, and I have also discovered a ready method for determining the density of the well fluid, the information so obtained being used to select the location of the pump at the most desirable level and for use in determining the production capacity of the well.

To obtain the information required, I measure or determine the stable location of the fluid surface of the "standing column" of fluid within the well when the pump is operating at its normal production capacity and with the pressure of gas within the casing at the usual or normal value maintained during the usual or normal pumping operations at the well. The expression "standing column" as used herein is intended to mean the column of well fluid which stands in the well as distinguished from the pumped liquid column which is being lifted to the ground surface by the pump, such standing column being known in the oil industry as the "dead" fluid column, and with the usual type of

Defendant's Exhibit S—(Continued)

pumping apparatus this standing column lies in the annular space between the tubing 5 and the casing 1.

This location of the fluid level may be readily accomplished by employing the methods and apparatus disclosed In United States Letters Patent No. 2,047,974, issued to Harold T. Wyatt and Paul E. Lehr, July 21, 1936, and in United States Letters Patent No. 2,156,519, issued to me on May 2, 1939, and in my copending application Serial No. 164,534, filed September 18, 1937. While the methods and apparatus are completely disclosed in the said patents and application, the method may be stated briefly as including the introduction into the annular space between the tubing 5 and the well casing of a sudden change in pressure in the well casing and measuring the length of time elapsing between the production of this pressure impulse and the return to the ground surface of the echo thereof from the surface of the fluid. Noting the distance from the ground surface of the fluid level under these conditions and noting the pressure of gas at the casing head, as by means of a pressure gage 13, the pressure on the fluid surface may be computed as follows: To the casing head pressure is added the effect of pressure on the fluid surface exerted by the weight of the column of gas between the fluid surface and the casing head. A gravity test may be made of the gas at the casing head which will determine the pressure exerted by each foot or

Defendant's Exhibit S—(Continued)

hundred feet of height of the gas column. This information may be computed by the following formula which is by Dice:

$$\text{Log}_{10}\text{Pb} = \frac{\text{SD}}{122.82\text{T}} + \text{Log}_{10}\text{Pt}$$

Where

Pb=Lbs. ∧ ~~sw.~~ sq. in. absolute at bottom of gas column.

Pt=Lbs./sq. in. absolute at top of gas column.

S=Specific Gravity of the gas (air is considered 1).

D=Depth from casing head to fluid surface.

T=Mean Temp. of the gas column in degrees F absolute.

This information may then be plotted upon a graph or chart as illustrated in Fig. 3 in which the conditions existing in the particular well under measurement are assumed to be such that with a pressure of 36 pounds per square inch at the casing head, the fluid surface is found to lie at 3100 feet below the casing head. The specific gravity of the gas in this instance may be found to be such that the effect will be to produce 4 pounds per square inch pressure on the fluid surface. Thus, the addition of 36 pounds and 4 pounds produces a total pressure on the fluid surface of 40 pounds per square inch. By arranging the chart shown in Fig. 3 with the ordinates representing the fluid level measured from the ground surface and the abscissae representing pressure on the fluid surface in pounds per square inch, the point L1 determined

Defendant's Exhibit S—(Continued)

from the preceding formula may be plotted on the chart shown in Fig. 3.

Now the valve 12 is closed or a suitable pressure regulator is placed in the gas line 11 and the pressure within the casing is allowed to build up to any predetermined value. As the pressure builds up, the fluid level 3 tends to recede, the pump drawing down the fluid column until a stable condition of production and fluid level is reached under the new gas pressure. By continuing the operations of the pump during the building up of this pressure, preferably for a period substantially equal to three times the length of time required for the pump to remove the column of fluid between the original fluid level and a new fluid level to which the pressure depresses the fluid surface, represented at 3a (Fig. 2), a stable condition will be achieved at which the fluid level will become constant and the production by the pump will be approximately the same as before the pressure was allowed to build up in the casing. When this stable condition is reached, a second measurement of the fluid level is obtained by the level measuring methods and apparatus hereinbefore described.

Having determined the new location of the fluid surface, the pressure exerted thereon may now be calculated as follows: Assuming that the casing head pressure in this instance was adjusted to 170 pounds, to this should be added the pressure due to the weight of the column of gas above the new fluid

Defendant's Exhibit S—(Continued)

level. The determination of the effect of the weight of the column of gas upon the fluid level may be obtained either by calculation or may be plotted out and obtained from suitable charts prepared for this purpose. In this instance, it may be assumed that the pressure due to the gas column is 30 pounds per square inch, making a total of 200 pounds per square inch on the fluid surface. Now, assuming that the level to which the standing column of fluid has receded is 3960/3966, feet from the top of the well, the new point L2 on the chart shown in Fig. 3 representing the new level and the pressure on the fluid surface may be placed upon the chart.

From an exhaustive series of actual tests I have discovered that in any given well which is being produced by a mechanical pump and where the cross sectional area of the standing fluid column is constant, there is a constant relation between a change in the pressure upon the fluid surface and the corresponding change in the location of the stable fluid surface for any given rate of production. This result follows from the fact, as I have discovered, that even though large quantities of gas bubbles are usually flowing vertically through the fluid column in a pumping well, the density of the gas and oil mixture in the column is constant throughout the height of the column. This is contrary to the usual concept of the fluid density in producing oil wells as heretofore it has been possible to explore, usually with a pressure recorder, the density

Defendant's Exhibit S—(Continued)

of the fluid in flowing wells only. These measurements are usually made in the flowing column of fluid where, on account of gas breaking out of the liquid as it flows up to regions of lower pressure, the fluid density is found to increase with the depth to which the pressure recorder is run in the column. Under equilibrium conditions in wells being produced by mechanical pumps there is evidently very little gas liberated from the liquid in the standing column, therefore the volume of gas which enters the column at the bottom is practically the same as that given off at the top. The constant density phenomena which I have discovered appears to be due to the fact that the size of the gas bubbles decreases and their density increases with their depth in the fluid column. They therefore travel much slower near the bottom than they do near the top of the fluid column where they are large and light. At the bottom therefore there are many small heavy gas bubbles traveling close together vertically upward at a slow rate whereas as these same bubbles approach the top of the column they become very large and light and travel at a high speed and are farther apart. The relations of bubble size, weight and velocity at different levels in the fluid column are evidently such that the proportions of gas and liquid are constant throughout the height of the column and the density does not change.

It follows therefore that an increase in pressure on the surface of the fluid column will cause the

Defendant's Exhibit S—(Continued)

column to recede through a distance directly proportional to the increase in pressure. Hence a line drawn on the chart shown in Fig. 3 intersecting the points L1 and L2 will truly represent the fluid level at any of the pressures which may be placed upon the column. Thus by merely extending the line C downwardly on the chart until it crosses the ordinate representing the location of the pump inlet indicated on the chart as A, a direct reading may be made from the chart of the pressure on the fluid surface which would be required to cause the surface of the column to recede to the pump inlet. On the chart this is represented as 336 pounds per square inch, which is the pressure exerted by the well fluid in that particular well at the pump entrance for the normal casing pressure and normal rate of production, assuming that the rate of production was normal during these tests.

The actual pressure in the column of fluid at the pump inlet may, however, be calculated from the information received by the two fluid level tests described above. That is, by subtracting the original fluid level from the new fluid level, the total difference in level will be found, in this instance 866 feet. Then by subtracting the original pressure on the fluid surface from the new pressure on the fluid surface, a difference of 160 pounds per square inch is found to have been necessary to cause the fluid column to recede 866 feet. By dividing the difference in fluid pressure by the difference in surface level, the density of the mixture of oil

Defendant's Exhibit S—(Continued)

and gas in the well (that is, the pressure exerted by this mixture per unit of height of the column of the mixture) may be found. In this instance, the column receded a distance between 3100 feet and 3966 feet, or a total distance of 866 feet, while the pressure difference is 160 pounds. The density of the fluid in the column is such therefore as to exert 0.185 pound per square inch per foot of height of the column.

Hence, knowing the pressure on the fluid surface at any level thereof and knowing the distance below this surface at which the pump inlet is located, a direct calculation of the fluid pressure at the pump inlet may be obtained by the following formulae:

The pressure at any point below the normal surface level in a well at which the level can be maintained by means of gas pressure in the casing is

$$PL1 = Pc1 + Pg1 \text{ and } PL2 = Pc2 + Pg2$$

The density of the fluid for the rate of production during the tests is

$$D = \frac{PL2 - PL1}{L2 - L1} = \text{density of the fluid in lbs. per sq. in. per foot of fluid.}$$

The pressure at the pump is

$$Pa = D(La - L2) + PL2$$

Where

Pc1 = gage casing pressure to maintain fluid at level L1.

Pc2 = gage casing pressure to maintain fluid at level L2.

Defendant's Exhibit S—(Continued)

Pg1 = pressure exerted upon fluid surface by weight of gas above it at level L1.

Pg2 = ditto for level L2.

PL1 = pressure on the fluid surface at level L1.

PL2 = pressure on the fluid surface at level L2.

L1 = fluid level corresponding to Pc1.

L2 = fluid level corresponding to Pc2.

La = pump location in feet from ground surface.

Pa = pressure at the pump.

In the example shown in Fig. 3, assuming the inlet to the pump is located at the 4700 foot level, the pressure of the fluid at this point would be equal to the sum of the gas pressure at the casing head for level L2, the pressure exerted by the column of gas above the fluid surface corresponding to this level and the pressure exerted by the column of fluid above the pump inlet. In this instance, the pressure at the casing head is assumed to be 170 pounds per square inch, the effect of the column of gas at this pressure with the fluid level at 3966 feet from the surface being 30 pounds per square inch and the effect of the column of fluid above the pump inlet being 734 feet at .185 pound per square inch per foot, or 135.5 pounds per square inch exerted by the column of fluid, the result being 335.5 pounds per square inch pressure at the pump entrance. This result is clearly illustrated in Fig. 3 by the point A, the point A being located at 335.5 mark on the abscissae of the chart.

If desired, an estimation of the bottom hole pres-

Defendant's Exhibit S—(Continued)

sure may also be made by continuing the line C downwardly on the chart to intersect the ordinate representing the bottom of the well, such point being indicated at B, or the pressure at any other level in the well below the surface of the well fluid for the rate of production at which the tests were made ~~and~~ may be located along the line C. I have discovered that in wells employing mechanical pumps for any given production rate by the pump, the density of the oil-and-gas mixture is constant throughout the height of the standing column of fluid in the annular space between the tubing and casing so that the line C once established continues as a straight line, the effect in pressure per unit of height of the column being constant throughout the height of the column.

Knowing the density of the well fluid and the pressure exerted at the pump inlet, the operator of any particular well may determine whether or not it is practicable to increase the amount of liquid being produced. If the volumetric efficiency of the pump is low and the tests indicate considerably pressure at the pump, he may raise the pump to a level indicated upon the line C at which better separation of gas will usually occur prior to entry of liquid into the pump.

The utilization of the information obtained by the foregoing method will also accurately produce the information of the maximum potential production of the well as by comparing the pressure of the fluid at the pump under two or more different

Defendant's Exhibit S—(Continued)

operating conditions of the pump. For example, the static fluid pressure at the pump when the pump is not operating may be measured and compared with the fluid pressure at the pump when the pump is operating at its normal rate of production or at any other rate of production, a comparison of the two values so obtained will produce a constant, indicating the ratio between the rates of production and pressure at the pump inlet, so that by employing this constant at a theoretical zero pump inlet pressure (which would represent the fluid being removed from the well at the rate it flows into the well from the formation) the maximum potential capacity of the well may be found.

Employing the method of determining fluid pressure at the pump hereinbefore described, the static pressure may be readily obtained without necessitating the use of pressure recorders or other devices requiring the removal of or alteration of any of the pumping mechanism and the measurement may be made in wells which have been shut down as readily as in wells which are actively producing.

To obtain the fluid pressure at any point at or below the fluid surface when the pump is not producing fluid, the casing should be closed in and the gas escaping from the well fluid should be allowed to build up pressure in the casing until a stable condition is reached, that is, a point is reached at which no more gas is made by the well (no more gas escapes from the well fluid). When this point is

Defendant's Exhibit S—(Continued)

reached, the remaining well fluid in the well may be considered as dense liquid.

Now, by determining the height of the fluid surface under these conditions by my method, the pressure on the fluid surface may be readily determined and by adding thereto the effect of the weight of the column of fluid above any given level, the fluid pressure at that level may be found. This information alone is extremely useful to the operators of producing wells.

The information thus obtained may be plotted on a graph or chart such as that shown in Fig. 4, wherein the ordinates represent fluid pressure at the pump inlet in pounds per square inch and the abscissae represents rate of production of oil from the particular well under consideration, and the static pressure may be plotted at zero production, as indicated by the point D in Fig. 4.

The casing pressure may now be reduced and the pump started and allowed to assume a predetermined rate of production, preferably its normal rate. Assuming this rate is 200 barrels of oil per day, a new determination of the fluid pressure at the pump is made at this rate of production. That is, the pump is started and allowed to operate until the fluid level in the well reaches a stable condition. The location of the fluid level and the pressure in pounds per square inch at the pump inlet under these conditions are determined by the method hereinbefore described and the fluid pressure at the pump is plotted against the production rate on the

Defendant's Exhibit S—(Continued)

chart shown in Fig. 4. Assuming that this new pressure at 200 barrels per day is found to be at the point indicated in Fig. 4 at E, a straight line drawn between the points D and E will intersect the zero pressure ordinate at a point representing the maximum potential capacity of the well. In the diagram shown in Fig. 4, this maximum potential production capacity is found to be 300 barrels per day. In other words, if a pump of sufficient capacity is installed in this well and operated in such manner as to remove 300 barrels per day, the oil will be removed at the same rate at which it flows into the well from the formation.

A more accurate determination of the maximum potential production capacity of the well may be made by comparing the fluid pressure at the pump under two different actual producing conditions of the pump, such as by measuring the fluid pressure at the pump when the pump is operating at one production rate, for example, its normal rate, and then changing the rate of production of the pump as by slowing the pump down or changing the stroke of the pump and plotting the relation between the new production rate and the fluid pressure measured by my method, as set forth herein, it will be found that a line intersecting these two points will also represent the relation between production rate and fluid pressure at the pump at any rate of the production by the pump.

As shown in Fig. 5, the normal production rate

Defendant's Exhibit S—(Continued)

of 200 barrels per day plotted against the fluid pressure at the pump in pounds per square inch may be represented upon the chart by the point G while at a reduced rate of production at the pump, say to 100 barrels per day, it will be found that the fluid pressure at the pump is increased so that by determining the fluid pressure under these conditions, the relation between the reduced production rate and the fluid pressure at the pump may be plotted by the point H. A straight line interconnecting the points H and G will intersect the zero pressure ordinate at a point therealong, indicating a maximum possible production of 300 barrels per day. In making such determinations, however, it is desirable that the rate of production of the pump be reduced to at least two-thirds of its normal production rate and preferably to 50% of its normal production rate in order to obtain substantially widely separated points H and G.

Again, it will be noted that all of the necessary calculations to determine the maximum production possible of the well may be made without interrupting the normal production conditions at the well and without requiring the laborous efforts of removing and replacing any of the pump mechanisms.

It will therefore be observed that I have provided a ready method for determining the density of the fluid in any particular well and also for the determination of the fluid pressure at the pump without requiring the removal or alteration of any of the usual mechanism found in the well. It will

Defendant's Exhibit S—(Continued)

also be noted that I have provided a ready method for graphically determining the fluid pressure at the pump by first determining the amount of recession of the fluid level due to changes in gas pressure exerted upon the fluid surface and plotting this information upon a graph or chart and extending a straight line intersecting the two or more points so located to a point on the chart representing the level of the pump inlet.

It will also be noted that I have devised a ready means for utilizing the information obtained with respect to fluid levels and gas pressures at the casing head for mathematically determining the fluid pressure at the pump and also for utilizing this information to determine accurately the potential production of any well measured. It should also be noted that all of the measurements necessary to provide for the computations and calculations explained herein may be accomplished without interrupting the operation of the pump except for the measurement of the static pressure as described herein.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details illustrated or described herein, except as defined in the appended claims.

H.W.M:M.M.

I CLAIM:

1. The method of determining the density of the standing column of fluid in a well, which comprises measuring the stable level of the fluid column under one condition of gas pressure, changing the pressure

Defendant's Exhibit S—(Continued)

of gas within the well to move the surface of the fluid column to a new stable level, measuring the new stable level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference in height between the two levels.

2. The method of determining the density of fluid in a well having a casing and a pump suspended therein on tubing and without requiring removal of pump parts, which consists in determining the fluid level in the annular space between the pump tubing and the casing under one condition of pressure, changing the pressure of the gas within the well to move the fluid surface to a new stable level, measuring the new level and dividing the change in pressure on the fluid surface required to achieve the new level by the difference between the two levels.

3. The method of determining the density of the standing column of fluid in a well having a casing and a pump suspended therein, which consists in measuring the level of the standing column of fluid in the well while the pump therein is operated at a given rate of production and under a known condition of gas pressure on the surface of the fluid column, changing the gas pressure on the fluid column, continuing the operation of the pump at the same production rate until the level of the standing column becomes stable at a new location, measuring the new level and comparing the difference in the pres-

Defendant's Exhibit S—(Continued)

sures exerted on the fluid surface at the two levels with the difference in height of the two levels.

4. The method of determining the density of the standing column of fluid in a well having a casing and a pump suspended therein, which consists in measuring the stable level of the surface of the standing column of fluid under one condition of pressure of gas released by the well, measuring the pressure on said fluid surface under said one condition of gas pressure, regulating the flow of gas from the well to increase the pressure of said gas to a different value to depress the surface of said standing column to a new stable level, measuring the new level, measuring the pressure on the fluid surface at the new level, and comparing the difference in the pressures exerted upon the fluid surface under the two conditions of gas pressure with the difference in height of the levels of the fluid surface under the two pressure conditions.

5. The method of determining the density of the standing column of fluid in an oil well having a casing and a mechanical pump suspended therein upon pump tubing and without requiring the removal of pump parts, which consists in the steps of operating the pump under one stable condition of gas pressure in the casing until the fluid level becomes stable, measuring the distance between the casing head and the surface of the fluid under this stable condition, altering the casing pressure to a new condition, operating the pump at the same rate of production under the new condition of gas pressure

Defendant's Exhibit S—(Continued)

to again stabilize the fluid level, measuring the distance between the casing head and the new level of the fluid surface under said new stable condition, and measuring the casing head pressures under the two stable conditions, whereby the pressure exerted by the fluid per unit of height of the fluid is represented by comparing the difference in height of the fluid surface levels and the difference between the pressures on the fluid surface required to maintain the fluid surface at the two levels.

6. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of fluid in the well at any desired level below the normal surface of said column and without requiring the removal of any of the pump parts, which comprises measuring the actual stable level of the fluid column under one known condition of gas pressure in the casing, determining the pressure on the fluid surface at that level, changing the pressure of gas in the well to move the surface of said column to a new actual stable level, measuring the new level of the fluid surface, determining the pressure on the fluid surface at the new level, determining the density of the fluid by dividing the change in pressure on the fluid surface required to achieve the new level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the pressure on the fluid surface at either of the levels the effect in pressure of the column of fluid of the density so determined be-

Defendant's Exhibit S—(Continued)

tween the selected actual level and the desired level.

7. In a well having a casing and a pump suspended therein, the method of determining the unknown pressure exerted in the standing column of fluid at any desired level below the normal surface of said column while the pump is operating to remove fluid from the well, which comprises measuring the actual stable level of the fluid under one known condition of gas pressure in the well by sonic sounding method, determining the pressure on the fluid surface at that level, changing the pressure of the gas in the well to move the surface of the column to a new actual level, continuing to operate the pump at the same production rate as for the first condition of gas pressure in the well until the fluid level again becomes stable, measuring the new stable level and determining the pressure upon the fluid surface at this new level, determining the pressure exerted per unit of height of the fluid column by dividing the change in gas pressure on the fluid surface required to effect the change in the fluid level by the difference in height of the two levels, and computing the unknown pressure at the desired level by adding to the gas pressure upon the fluid surface at either of the actual levels the effect in pressure of the fluid column between the selected actual level and the desired level.

8. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises measur-

Defendant's Exhibit S—(Continued)

ing the stable level of the surface of the standing column of fluid in the well at one known rate of production and under one known condition of gas pressure in the well, determining the the pressure on the surface of the fluid column at that level, changing the gas pressure in the well to move the surface of the fluid column to a new stable level, measuring the level of the fluid surface under the new gas pressure condition and determining the pressure on the fluid surface at the new level, dividing the change in pressure on the fluid surface by the difference in height between the two levels to thereby determine the density of the fluid in the column at that rate of production, determining the pressure at some predetermined desired point below the normal fluid surface for that rate of production by adding to the pressure on the fluid surface for either of the measured levels the effect in pressure of the column of fluid between that level and the predetermined desired point, then changing the rate of production by the pump and repeating the fluid level change and gas pressure determination to determine the density of the fluid in the column and the pressure of the fluid at the said predetermined desired point for the new rate of production and then dividing the difference in the two production rates by the difference in the corresponding fluid pressure at the desired point and using the ratio thus found to determine the maximum rate at which the well is capable of being produced.

Defendant's Exhibit S—(Continued)

9. The method of ascertaining the pressure exerted by the well fluid at any point below the normal surface thereof, which comprises: determining the location of the fluid surface under one condition of pressure of gas on the surface, determining said gas pressure under said one condition, changing the gas pressure to move the fluid surface to a new stable level, determining the new gas pressure on the fluid surface, determining the location of the new surface level and comparing the difference in said gas pressures with the corresponding change in height of the surface level to determine the relation between them, whereby the gas pressure one the fluid surface which is required to maintain the fluid surface at any selected point may be ascertained and which pressure represents the normal pressure exerted in the fluid at said point.

10. The method of ascertaining the pressure exerted by the well fluid at any point below the surface thereof while a mechanical pump is operating in that well, which comprises: determining the stable location of the fluid surface under one condition of gas pressure in the casing of the well; determining the gas pressure on the fluid surface at that level; changing the pressure of gas in the casing to move the fluid surface to a new stable level; determining the new location of the fluid surface; determining the gas pressure on the surface at the new level; and comparing the difference between the pressures on the surface with the corresponding change in the height of the fluid surface to

Defendant's Exhibit S—(Continued)

thereby determine the relation between changes in pressure on the fluid surface and the corresponding changes in the location of said fluid surface from which relation the pressure at any selected point may be ascertained.

11. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises: determining the pressure exerted by the well fluid at some selected point below the normal surface thereof under one known rate of production, by determining the location of the fluid surface under one condition of gas pressure on the surface, determining the gas pressure on the fluid surface under said one condition, changing the gas pressure to move the fluid surface to a new stable level under the same production rate, determining the new gas pressure on the fluid surface, determining the location of the new surface level, comparing the difference in said gas pressures with the corresponding change in height of the surface level, to thereby ascertain the pressure exerted at said selected point under said one rate of production; changing the rate of production from said well; repeating the steps of determining the location of the fluid surface at two stable levels and the gas pressures on said surface to maintain said levels under the new production rate to ascertain the pressure exerted at the same selected point; and comparing the difference in the production rates with the corresponding dif-

Defendant's Exhibit S—(Continued)

ference in pressures at said selected point to determine their relation from which the maximum rate of production from the well may be determined.

In testimony whereof, I affix my signature at San Marino, in the County of Los Angeles, State of California, this 15th day of November, 1939.

CRANFORD P. WALKER.

In the United States Patent Office

Re: United States Letters Patent
No. 2,161,733

CRANFORD P. WALKER

METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND THE PRODUCTION CAPACITY OF OIL WELLS

Issued: June 6, 1939
Application Filed: October 26, 1937
(Serial Nos. 171,170 and 268,805)

REISSUE OATH

State of California
County of Los Angeles—ss.

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he does verily believe himself to be the original, first and sole inventor of the improvement set forth and

Defendant's Exhibit S—(Continued)

claimed in the foregoing specifications, and for which improvement he solicits a patent; that deponent does not know and does not believe that the said improvement was ever before known or used; that deponent is a citizen of the United States of America and resides at San Marino, in the County of Los Angeles, State of California; that deponent verily believes that the Letters Patent referred to in the foregoing Petition and Specifications, and herewith surrendered, are inoperative or invalid for the reason that the specifications thereof are defective and insufficient and that such defect and insufficiency consists particularly in:

(1) The employment in the original specification of expressions "liquid column", "fluid column", "liquid surface", "fluid surface", "fluid level", and "liquid level" interchangeably throughout the specification, whereas in order to more accurately understand the teachings of the specification a clear line of definition should be maintained between the natural well fluid which is a compressible mechanical mixture of liquid (oil and water) and gas entrapped therein as distinguished from the dense liquid (oil or water and oil) after the gas has been separated therefrom. This defect is cured in the reissue application by accurate use of the terms "well fluid", "fluid level", "fluid surface" and "fluid column" in reference to the natural well fluid in the well and the accurate use of the expressions "liquid" or "dense liquid" to refer to the separated oil.

Defendant's Exhibit S—(Continued)

(2) The obviously incorrect statement on Page 2 of the specifications that densities range "from less than .04 pound per square inch to over .4 pound per square inch per 100 feet of fluid", when such statement should read "per foot of fluid".

(3) Failure of the original specification to include an explanation of the phenomena encountered in the column of natural well fluid in the well by which the density of the mixture of dense liquid and gas is constant throughout the height of the column. This explanation was presented to the Examiner at the oral interview but was not incorporated in the body of the specification. This explanation is incorporated in the reissue specification and avoids the erroneous impression that increase in pressure upon the fluid surface causes the fluid to be driven back into the formation when in fact this fluid under the increased pressure merely speeds up the production rate from the well until the displaced fluid has been removed by the pump whereupon stable conditions under the new ressure are resumed. This explanation assists materially in an understanding of the applicant's method and accounts for the startling results achieved by the applicant.

(4) The failure of the original specification to include the following claims:

> 9. The method of ascertaining the pressure exerted by the well fluid at any point below the normal surface thereof, which comprises: de-

Defendant's Exhibit S—(Continued)

termining the location of the fluid surface under one condition of pressure of gas on the surface, determining said gas pressure under said one condition, changing the gas pressure to move the fluid surface to a new stable level, determining the new gas pressure on the fluid surface, determining the location of the new surface level and comparing the difference in said gas pressures with the corresponding change in height of the surface level to determine the relation between them, whereby the gas pressure on the fluid surface which is required to maintain the fluid surface at any selected point may be ascertained and which pressure represents the normal pressure exerted in the fluid at said point.

10. The method of ascertaining the pressure exerted by the well fluid at any point below the surface thereof while a mechanical pump is operating in that well, which comprises: determining the stable location of the fluid surface under one condition of gas pressure in the casing of the well; determining the gas pressure on the fluid surface at that level; changing the pressure of gas in the casing to move the fluid surface to a new stable level; determining the new location of the fluid surface; determining the gas pressure on the surface at the new level; and comparing the difference between the pressures on the surface with the corresponding change in the height of the fluid

Defendant's Exhibit S—(Continued)

surface to thereby determine the relation between changes in pressure on the fluid surface and the corresponding changes in the location of said fluid surface from which relation the pressure at any selected point may be ascertained.

11. The method of determining the potential production capacity of a well having a casing and a pump suspended therein, which comprises: determining the pressure exerted by the well fluid at some selected point below the normal surface thereof under one known rate of production by determining the location of the fluid surface under one condition of gas pressure on the surface, determining the gas pressure on the fluid surface under said one condition, changing the gas pressure to move the fluid surface to a new stable level under the same production rate, determining the new gas pressure on the fluid surface, determining the location of the new surface level, comparing the difference in said gas pressures with the corresponding change in height of the surface level, to thereby ascertain the pressure exerted at said selected point under said one rate of production; changing the rate of production from said well; repeating the steps of determining the location of the fluid surface at two stable levels and the gas pressures on said surface to maintain said levels under the new production rate to ascertain the pressure exerted at the

Defendant's Exhibit S—(Continued)

same selected point; and comparing the difference in the production rates with the corresponding difference in pressures at said selected point to determine their relation from which the maximum rate of production from the well may be determined.

Deponent further says that the errors which render such patent inoperative or invalid arose from inadvertence, accident and mistake, and without any fraudulent or deceptive intention on the part of deponent; that the following is a true specification of the errors which it is claimed constitute such inadvertence, accident or mistake relied upon:

As to the omission of the explanation of the density and pressure phenomena which takes place in the practice of applicant's method, at the time the original application was filed deponent believed that the explanation of the phenomena discovered by applicant was sufficient to permit a ready understanding of the invention but that subsequent to the issue of said patent persons reading the same have questioned applicant as to this phenomena. Wherefore applicant discovered that such missing explanation if supplied would materially assist in a ready understanding of his invention.

That as to the original specification reciting the terms "fluid", "fluid surface", "liquid" and "liquid surface" interchangeably, the applicant has dscovered that persons reading the patent tend to become confused as between the natural well fluid and the dense oil or liquid.

Defendant's Exhibit S—(Continued)

That as to Claims 9 and 10 submitted herewith, these claims are directed to the same subject matter as Claim 6 of the original patent but omit the limitation of the arithmetical steps of division and addition. At the time the original patent was issued, the applicant considered that these claims were sufficiently broad in scope to cover the graphic representation and graphic comparison between the pressures and fluid levels as shown in Fig. 3 and as described in the original patent, Page 3, Column 2, Line 13 to Page 4, Column 1, Line 11, and Page 4, Column 2, Lines 21 through 38, with particular reference to the explanation of the use of the chart described in the original patent, Page 4, Column 1, Lines 7 through 17, and Page 4, Column 2, Lines 21 through 29, wherein the method of ascertaining the pressure existing at points below the liquid surface other than those to which the fluid is actually depressed but without requiring any actual computation of arithmetical divisions or additions. It was only after the patent issued and immediately prior to the filing of this reissue that applicant's attention was called to the fact that Claim 6 might require interpretation in order to insure its readability on the graphic representation shown in Fig. 3 and described in the parts of the specification noted.

With respect to new Claim 11, this claim is directed to the same subject matter as Claim 8 but, like new Claims 9 and 10, omits the limitation of

Defendant's Exhibit S—(Continued)

arithmetical calculations. Again applicant at the time the original patent issued believed that these claims were sufficiently broad in scope to cover the graphic representations shown in Figs. 4 and 5 and it was not until subsequent to the issuance of the patent and attempts to exploit the patent that this defect was called to his attention as possibly requiring interpretation of the claims to enable them to be read upon the disclosure of Figs. 4 and 5 and the description hereinbefore referred to.

That the deponent has just discovered the foregoing defects and has lost no time in making this application for reissue of said patent.

That the errors hereinbefore pointed out and so particularly specified arose from the fact that applicant considered that graphic comparisons between the values ascertained by his method and arithmetical computation employing these values were and are the equivalents of each other and it was not until in attempting to exploit the invention that it was called to his attention that a possible narrow interpretation could be placed upon these claims and applicant has immediately thereafter made this application for reissue.

CRANFORD P. WALKER

Subscribed and sworn to before me this 15th day of November, 1939.

MARJORIE McKAY

Notary Public in and for the County of Los Angeles, State of California.

My commission expires July 14, 1941.

Defendant's Exhibit S—(Continued)

Petitioner requests that the original drawings upon which his patent was granted may be used as the drawings in this reissue application.

Signed at San Marino, in the County of Los Angeles, State of California, this 15th day of November, 1939.

CRANFORD P. WALKER

(SURRENDERED)

No. 2161733

The United States of America

To All to Whom These Presents Shall Come:

Whereas Cranford P. Walker, of San Marino, California, presented to the Commissioner of Patents a petition praying for the grant of Letters Patent for an alleged new and useful improvement in

> Methods of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells,

a description of which invention is contained in the specification of which a copy is hereunto annexed and made a part hereof, and complied with the various requirements of Law in such cases made and provided, and

Whereas upon due examination made the said Claimant is adjudged to be justly entitled to a patent under the Law.

Now therefore these Letters Patent are to grant unto the said Cranford P. Walker, his heirs or

Defendant's Exhibit S—(Continued)

assigns for the term of Seventeen years from the date of this grant the exclusive right to make, use and vend the said invention throughout the United States and the Territories thereof.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this sixth day of June, in the year of our Lord one thousand nine hundred and thirty-nine, and of the Independence of the United States of America the one hundred and sixty-third.

(Seal) CONWAY P. COE
Commissioner of Patents

Attest:

H. S. MILLER
Law Examiner.

307551

[Printer's Note: Copy of Patent No. 2,161,733, issued to C. P. Walker for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, attached here, is not reproduced as it is set out in full as Defendant's Exhibit O-1, in this Book of Exhibits.]

D.V. 3

51 Oil Well

307551

June 6, 1939. C. P. WALKER 2,161,733

METHOD OF DETERMINING FLUID DENSITY, FLUID PRESSURE, AND THE PRODUCTION CAPACITY OF OIL WELLS

Original Filed Oct. 26, 1937

Print of drawing as originally filed.

Re 383

3-5

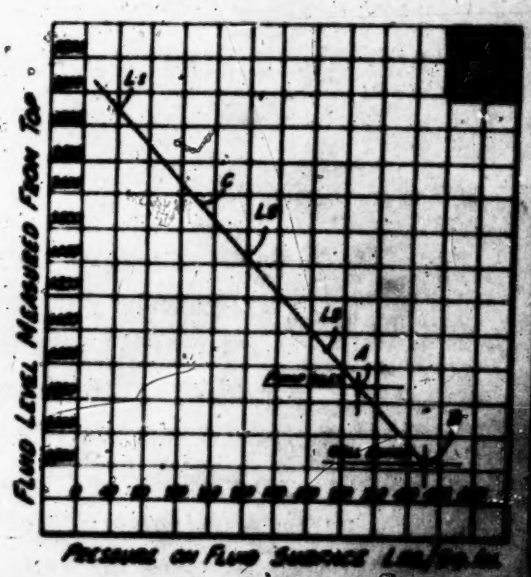
CLASS 51 SUB. CLASS

31 166 39

FIG. 1.

FIG. 2.

FIG. 3.



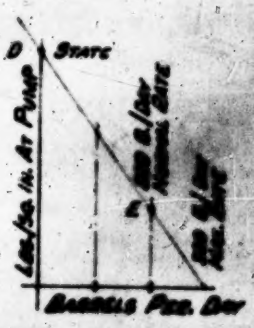


FIG. 4.

FIG. 5.

INVENTOR
CRAWFORD P. WALKER
BY
ATTORNEY.

307551 41 B51

36

Defendant's Exhibit S—(Continued)

In the United States Patent Office

U. S. Patent Office Dec 13 1939 Division 36

Re: United States Letters Patent No. 2,161,733

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Issued: June 6, 1939

Application Filed: October 26, 1937

(Serial Nos. 171,170 and 268,805)

ORDER FOR COPIES OF DRAWINGS

Hon. Commissioner of Patents

Washington, D. C.

Sir:

In the matter of the above entitled application for reissue Letters Patent, please furnish photostatic copies of the drawings in United States Letters Patent No. 2,161,733, granted to Cranford P. Walker on June 6, 1939, for Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells, for substitution in said patent file so that the original drawings may be used as a part of this reissue application, charging the cost of same to my Miscellaneous Fees Account.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant

Dated: November 15th, 1939.

[Longhand Note]: This letter to be placed in reissue appln. Div. 36. Ser. No. 307551.

[Longhand Note]: 1 Print ordered by appln. div. charge 20 P.

Defendant's Exhibit S—(Continued)

In the United States Patent Office

U. S. Patent Office Dec 12 1939 Division 36

Re: United States Letters Patent No. 2,161,733

Cranford P. Walker

Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells

Issued: June 6, 1939

Application Filed: October 26, 1937

(Serial Nos. 171,170 and 268,805)

POWER OF ATTORNEY

Hon. Commissioner of Patents

Washington, D. C.

Sir:

In the matter of my reissue application of United States Letters Patent No. 2,161,733, I hereby appoint Harold W. Mattingly, Registry No. 12,385, 621 South Hope Street, Los Angeles, California, my attorney with full power of substitution and revocation, to prosecute the said application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith, and request that all correspondence be conducted with said Harold W. Mattingly at the above address.

Signed at San Marino, in the County of Los Angeles, State of California, this 15th day of November, 1939.

CRANFORD P. WALKER

[Longhand Note]: No assignment of record thru Dec. 4/39.

Defendant's Exhibit S--(Continued)

Buchler/R

Div. 36 Room 7892

Department of Commerce
United States Patent Office
Washington
Paper No. 3

All communications respecting this application should give the serial number, date of filing, and name of the applicant
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

Mailed Jan 24 1940.

Please find below a communication from the EXAMINER in charge of this application

CONWAY P. COE
Commissioner of Patents.

Harold W. Mattingly,
621 S. Hope St.,
Los Angeles, Calif.

Applicant Cranford P. Walker
Ser. No. 307,551
Filed Dec. 4, 1939
For Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells

In accordance with the provisions of Order No. 2308, dated March 12, 1917, which reads in part as follows:

* * * * * * * *

Defendant's Exhibit S—(Continued)

Obvious informalities in the application may be corrected by the examiner, but said correction must be in the form of an amendment, approved by the Principal Examiner in writing, placed in the file, and made a part of the record. The changes specified in the amendment will be entered by the clerk in the regular way.

* * * * * * * *

the changes, hereinafter specified, are made by the examiner in the application above identified.

Should these changes not be satisfactory to the applicant, appropriate amendment may be proposed under the provisions of Rule 78, provided the specification has not been printed.

The application has been amended as follows:

In line 16 of page 11, sq. has been substituted for "sw."

In line 10 of page 14, volume has been substituted for "volumn."

In line 14 of page 13, 3966 has been substituted for "3960."

In line 4 of page 18, "and" has been canceled.

A. D. McFADYEN
Examiner

Defendant's Exhibit S—(Continued)

Serial No. 307,551

Address only
Commissioner of Patents
Washington, D. C.
Department of Commerce
United States Patent Office
Washington

Cranford P. Walker,
San Marino, Calif.

Sir:

Your application for Reissue for Patent No. 2,161,733, for improvement in Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells (11 claims) has been examined and allowed.

The patent will be forwarded to you as soon as practicable, in due order of business.

Very respectfully,
CONWAY P. COE
Commissioner of Patents.

Harold W. Martingly,
621 S. Hope St.,
Los Angeles, Calif.

Mailed Jan 26 1940.
Patent Mar 5 1940 Will Issue.

Defendant's Exhibit S—(Continued)

401

Div. 36

TITLE REPORT

No. 2,161,733

Name Cranford P. Walker

The title appears from the assignment records to be vested in:

Inventor

Examined up to and including Nov. 28, 1939

This certificate dated Dec. 7, 1939

C. H. GRAY

Chief of Assignment Division.

H

No further assignments appear to have been received for record including

1/24/40.

[Printer's Note: Copy of Reissue patent No. 21,383, to C. P. Walker, for Method of Determining Fluid Density, Fluid Pressure, and the Production Capacity of Oil Wells, attached here, is not reproduced, as it is set out in full as Plaintiffs' Exhibit No. 2, in this Book of Exhibits].

District Court of the United States

Southern District of California—Central Division

Honorable Commissioner of Patents,

Washington, D. C.

Sir:

In compliance with the Act of February 18, 1922

Defendant's Exhibit S—(Continued)

(42 Stat. L. 392), you are advised that there was filed on the 16th day of July, 1941, ~~193~~ , in this court an action, suit, or proceeding No. 1655-H-Civ. entitled:

Name Cranford P. Walker, etc., et al., Plaintiffs,
Address Los Angeles, California,

versus

Name Halliburton Oil Well Cementing Co., a Delaware corp., Defendant,
Address Los Angeles, California.

brought upon the following patents:

	Patent No.	Date of Patent	Patentee
1.	2,156,519	May 2, 1939	Cranford P. Walker
2.	2,161,733	June 6, 1939	Cranford P. Walker
3.	Reissue 21,383	Mar. 5, 1940	Cranford P. Walker

In the above-entitled case the following decision has been rendered or decree issued:

In Witness Whereof I have affixed my hand this 16th day of July, 1941, ~~193~~ , at Los Angeles, Calif.

R. S. ZIMMERMAN,
Clerk of said Court.
By L. WAYNE THOMAS
L. Wayne Thomas, Deputy Clerk.

Defendant's Exhibit S—(Continued)

423

1939

Contents

Application . . . . . papers:

1. Print 12-8-39
2. Exr amdt A Jan. 24, 1940
3. Notice of suit July 21-1941

[Endorsed]: Filed Nov. 9, 1942.

DEFENDANT'S EXHIBIT T

390

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come, Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents in the matter of the

Letters Patent of
Cranford P. Walker,
Number 2,156,519, Granted May 2, 1939,
Improvement in Means for Measuring the Location of Obstructions in Wells.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this seventh day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

(Seal) CONWAY P. COE
Commissioner of Patents.

Attest:

D. E. WILSON
Chief of Division.

1416

NUMBER 102699

PRINTED FILE 1937
TURN TO RECORD ROOM

PATENT No. 2156519

DIV. 47 5

DATED MAY -2 1939

(EX'R'S BOOK)

Name CRANFORD P. WALKER

of SAN MARINO

State of CALIFORNIA

Invention METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Division of App., No. , Filed , 19

DATES OF APPLICATION FILED	ORIGINAL	RENEWED
APPLICATION FILED COMPLETE	SEPT 7, 1937	
Petition, Specification, Oath, First Fee $30, 2 sheets Drawings,	SEPT 7, 1937	
17 EXTRA CLAIMS $17	SEPT 7, 1937	

Examined and passed for Issue Mar. 21, 1939

R. W. Robertson Exr. Div. 5

Notice of Allowance Mar. 21, 1939 By Commissioner.

Final Fee $30 Apr. 3, 1939

Reexam'd and passed for Issue , 193

Exr. Div.

Notice of Allowance , 193 By Commissioner.

Final Fee , 193

Attorney HAROLD W. MATTINGLY 924 PACIFIC FINANCE BLDG 621 S. HOPE ST LOS ANGELES CALIF

Associate Attorney

No. of Claims Allowed 17 Print Claims 7 - 13 in O.G. Class 181-0.5

Title as allowed Means For Measuring the Location of obstructions in Wells

Defendant's Exhibit T—(Continued)

Sep—7-37 43334 K—Check—30.00.
Sep—7-37 43334 K—Check—17.00.
Mail Division Sep 7 1937 U. S. Patent Office.

Harold W. Mattingly
Attorney at Law
Patent and Trademark Causes
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
MAdison 1137

1/85

September 2, 1937.

Commissioner of Patents,
Washington, D. C.

Sir:

Attached is application for Letters Patent of the United States executed August 31, 1937 by Cranford P. Walker; also attached is my check No. 201 in the amount of $47.00 to cover the Government filing fee (37 claims).

Respectfully,
HAROLD W. MATTINGLY

MM
Encls.

Defendant's Exhibit T—(Continued)
Mail Division Sep-7 1937 U. S. Patent Office.

PETITION

Received Sep 16 1937.
Division 5, Paper No. .....

To the Commissioner of Patents:

Your petitioner, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and the State of California, whose post office address is 2824 Carlaris Road, San Marino, California, prays that Letters Patent may be granted to him for the ~~Method and~~ Means for Measuring the Location of Obstructions in Wells set forth in the annexed specification, and he hereby appoints

Harold W. Mattingly
924 Pacific Finance Building
621 South Hope Street
Los Angeles, California
(Registry No. 12,385)

his attorney, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

(Sign here first name in full)

CRANFORD P. WALKER

Defendant's Exhibit T—(Continued)

SPECIFICATION

To All Whom It May Concern:

Be It Known, That I, Cranford P. Walker, a citizen of the United States, residing at San Marino, in the County of Los Angeles, and State of California have invented certain new and useful improvements in ~~Method and~~ Means for Measuring the Location of Obstructions in Wells of which the following is a specification:

My invention relates to ~~a method of~~ devices for measuring the location of obstructions in deep wells, such as oil wells, and has particular reference to ~~methods and~~ apparatus for determining the location below the ground surface of the liquid level in the well or the location of tools, pipe sections, couplings or other devices which constrict the well bore.

During the active life of an oil well it is desirable from time to time to determine the location of the fluid level within the well for the purpose of determining the type of pumping apparatus most desirable to be used, determining the rate of flow of oil into the well, and for making other determinations desirable in the most efficient operation of the well.

Prior methods of determining the location of the fluid level or the location of other obstructions in the well have been generally of two types, one in which measuring apparatus has been lowered from the ground surface to determine by the length of cable or line extended into the well the depth or location

Defendant's Exhibit T—(Continued)

of the fluid or other obstructions encountered by the instrument as it is lowered. Among devices to be lowered into the well is also included a pressure recorder which may be lowered into the well on a wire, the length of which is metered to determine the static pressure in the well at different levels, a variation of which includes a pressure recorder with a clock driven chart lowered on the bottom of the pump to obtain a record of the operating pressures or levels of the fluid. A further variation is that of lowering a bailer upon a rope and either measuring the wetted surface of the rope or repeatedly lowering the bailer until it brings up fluid, measuring the length of the line upon such occurrence. The other method is that of producing sound waves in the well and noting the elapsed time between the introduction of the sound and its return as an echo from the surface of the fluid or other obstruction encountered.

Neither of these methods is satisfactory, the first having the disadvantage of requiring the removal of oil flow tubing, sucker rods and other apparatus normally disposed in the well prior to the time the instrument is inserted in and lowered into the well, requiring a considerable length of time both for the removal of such apparatus, the reinsertion of the apparatus, and the making of the actual measurement. The other method is unsatisfactory primarily because of the relatively low intensity or energy which can be employed in the sound wave so that the echo received back is of such low energy as to prevent its accurate detection and, further, little or no

Defendant's Exhibit T—(Continued)

distinction is made by reason of such low energy between various types of obstructions encountered by sound wave.

A third method, namely, that of introducing a shock of relatively high intensity into the well, creating thereby a pressure wave which travels through the well, and measuring the elapsed time between the introduction thereof and the echo thereof, to give an indication of the depth of the fluid level and other obstructions, has been introduced, one form being that of creating an explosion in the well, another form being illustrated and described in United States Letters Patent No. 2,047,974, issued to Harold J. Wyatt and Paul E. Lehr on July 21, 1936. This latter method has the desirable characteristic of permitting the employment of relatively high intensity in the wave or impulse produced in the well and it is an object of my invention to improve upon the method disclosed in that patent and to eliminate or materially reduce factors of error encountered in the employment of that method.

Another object of my invention is to provide a method and apparatus for measuring the location of fluid level or other obstructions in well bores, in which the intensity of the pressure impulse introduced into the well may be varied to compensate for well depth and the character of the gaseous media through which the wave must travel to produce an echo of sufficient intensity to permit the same to be readily detected and translated.

Defendant's Exhibit T—(Continued)

~~Another object of my invention is to provide a~~ method and apparatus as set forth in ~~the~~ preceding paragraph wherein the pressure impulse may be so varied as to allow ~~the~~ detection and the separate determination of the location of a plurality of ob~~structions which may be encountered in the well~~.

Another object of my invention is to provide a device ~~method~~ for the measurement of the location of fluid level or other obstructions in a well bore in which the pressure impulse introduced into the well produces an indication both of the fluid level and of the location of other obstructions in the well bore.

Another object of my invention is to provide an ~~a method and~~ apparatus of the character set forth in the preceding paragraph wherein the same pressure impulse introduced into the well to measure the fluid level or the location of other obstructions is employed to determine the velocity of the wave in the particular media encountered in the well.

Another object of my invention is to provide an ~~a method and~~ apparatus as set forth in the preceding paragraph wherein, knowing the location of one or more obstructions, tools or other devices in the well bore, the velocity of the wave within the well bore may be accurately determined from echoes produced thereby and enabling an operator to determine the unknown location of the fluid level by the mere measure of the elapsed time between the introduction of the impulse into the well and the recep-

Defendant's Exhibit T—(Continued)

tion of a distinguishable echo from the fluid level, without necessitating introduction of corrective factors or other separate measurement of and determination of the character of the media in the well.

Another object of my invention is to provide an ~~a method and~~ apparatus for determining the location of fluid levels in well bores in which the location of and the number of tubing sections in the well may be determined by the same pressure wave created to measure the depth or the location of the fluid level.

~~Another object of my invention is to provide a~~ method as set forth in which when the location of none of the obstructions, tools or other devices in the well is known, a measurement and determination of the character of the media in the well may be made to accurately determine the velocity of the wave in ~~the particular well under consideration.~~

Other objects of my invention will be apparent from a study of the following specifications, read in connection with the accompanying drawings, wherein

Fig. 1 is a diagrammatic view illustrating a typical well cross section and the location and character of the apparatus required for determining the fluid level or location of other obstructions in the well in accordance with my method;

Fig. 2 is a diagrammatic view illustrating the type of record or indication which may be made with my method in its simplest application;

Defendant's Exhibit T—(Continued)

Fig. 3 is a diagrammatic view similar to Fig. 2 and illustrating the type of record or indication which may be made with my method but in which echoes produced by intermediate obstructions are not amplified;

Fig. 4 is a diagrammatic view similar to Figs. 2 and 3 and illustrating the type of record or indication which may be made with my method, including the aplification of echoes from intermediate obstructions; and

Fig. 5 is a vertical sectional view taken through one form of mechanical pressure responsive device which may be employed in my method.

The method disclosed in United States Letters Patent issued to Wyatt and Lehr, hereinbefore referred to, is briefly that of introducing into a well bore a pressure impulse, either positive or negative, which may have any desired frequency as by the introduction into the well of a quantity of gas of known pressure and volume, the introduction of this impulse into the well producing a wave which will travel down the well until it encounters the fluid surface in the well and then the wave will be reflected and will travel back up the well to the ground surface where the echo or return wave may be detected, the measurement of the elapsed time between the production of the impulse and the arrival at the ground surface of the echo constituting a measure of the location of the fluid level by the simple calculation of the elapsed time multiplied by the rate of travel or the velocity of the

Defendant's Exhibit T—(Continued)

wave in the well. In making such calculations, it is correctly assumed that the velocity of the wave will be the same as that of a sound wave. In air at normal temperatures and approximately sea level pressures, this rate would be 1100 feet per second but the gaseous content or media in the well is ordinarily not the same as air and correction must be made for the density, temperature or other characteristics of the particular media encountered in the well, it being well known that the higher the temperature or the lower the density of the gaseous media through which the impulse travels, the greater the velocity of the wave.

In employing the method as set forth in the said patent, an approximation of the fluid level may be readily determined and this approximation or measurement may be determined in a relatively short length of time, without requiring the removal or disturbance of any of the apparatus contained within the well bore. However, to determine the fluid level with considerable accuracy, the rate of travel of the wave in the particular media encountered in any particular well must be known or must be determined since the density, temperature and character of the gaseous media in wells varies in each different oil field and in each individual well. I provide means for readily determining at any particular well the velocity of the wave in that particular well, which may be arrived at as follows:

Defendant's Exhibit T—(Continued)

In Fig. 1 I have illustrated a typical oil well comprising the earth bore 1, usually lined with casing 2 or pipe of relatively large diameter, extending from the ground surface at 3 to the oil bearing sands at 4 where the casing is either perforated or is provided with a perforated liner through which the oil from the sands may enter to the interior of the casing. The casing is, of course, constructed of a plurality of lengths of pipe secured together by couplings or collars in any well known manner. A second pipe or string of pipes extend down through the casing 2, this string of pipe being known as the oil flow tubing, indicated at 5, extending from the ground surface down to a position disposed below the level of the fluid in the well, which is indicated at 6, the lower end of the tubing string 5 having a pump 7 of any desired character located therein. Such pumps are usually operated by means of a string of sucker rods 8 which extend upwardly through the tubing string 5.

It is the common practice to employ in the tubing string 5 a tubing catcher 9 which may be of any of the well known constructions, the tubing catcher being usually located a relatively short distance above the level of the fluid in the well so that should the tubing string break the tubing catcher 9 will grip the casing and prevent complete destruction of the tubing string. One or more of the tubing catchers 9 may be distributed throughout the length of the tubing string 5.

Defendant's Exhibit T—(Continued)

The tubing string 5 is constructed of a plurality of lengths of pipe coupled together by means of collars 10, which collars are usually of somewhat larger outside diameter than the outside diameter of the tubing from which the oil flow tubing is made.

Hence it will be noted that in the ordinary oil well there are a plurality of obstructions, each of which is capable of receiving and reflecting a sound wave or pressure wave passing down through the well, these obstructions including the fluid surface 6, the tubing catcher 9 and each of the collars 10 of the tubing string.

In most wells the length of the tubing string between the ground surface 3 and the pump 4 is known, that is, records are usually kept showing the length of each tubing string section and the number of such sections located within any given well. Particularly, records are usually kept as to the location along the tubing string of the catcher 9 so that by referring to these records an absolute calculation or determination of the distance between the ground surface and the tubing catcher or liner top is known. Hence to determine the location of the fluid level 6, it is only necessary to produce in the well a pressure impulse which will create the low frequency wave, and then translate the echoes received from the well in terms of echo impulses received from the tubing catcher or liner top and from the liquid surface. By comparing the time lapse between the production of the pressure impulse and the receipt of the echo from the tubing

Defendant's Exhibit T—(Continued)

catcher with the time lapse between the creation of the pressure impulse and the receipt of the echo from the fluid surface, a positive and accurate measurement of the location of the fluid level may be obtained. That is, if the known location of the tubing catcher is 5000 feet below the fluid surface and it is desired to know the height of the fluid in the well, all that is necessary is to produce a pressure impulse, note or record the echo from the tubing catcher, and note or record the echo received from the fluid surface. The time lapse between the creation of the pressure impulse and the receipt of the echo from the tubing catcher denotes the velocity of the pressure wave in the particular media encountered in that particular well so that by measuring the additional elapsed time between the receipt of the echo from the tubing catcher and the receipt of the echo from the fluid surface, an accurate measurement may be obtained and no compensation need be made for possible errors due to different velocities of waves in different media because the mean velocity of the wave from the ground surface to the tubing catcher and return is exactly the same as the mean velocity of the wave from the ground surface to the fluid surface and return.

The only item which must be provided for is that of producing a pressure wave echo of such magnitude and of such character that the echo from the tubing catcher can be distinguished from the echo received from the fluid surface.

Defendant's Exhibit T—(Continued)

As illustrated in Fig 1, this distinction may be readily made by providing a suitable source of fluid pressure indicated at 11 which may be a tank, compressor or other source of fluid pressure at any desired value. It follows, of course, that the pressure impulse which must be produced in the well must be at a greater pressure than the pressure of gases in the well so that the pressure source 11 must be capable of delivering a pressure impulse having a considerable differential over the static pressure of gases in the well or flowing therefrom. For example, if the well gases at the surface of the well are at a pressure of 500 pounds per square inch, the source of fluid pressure 11 must be capable of delivering, say, 600 pounds per square inch or more in order to create a pressure impulse of, for example, 100 pounds pressure differential.

The pressure source 11 is illustrated as being coupled to a pressure chamber 12, one end of which is connected as by means of tube 13 and valve 14 to the pressure source 11, while the opposite end of the pressure chamber 12 is connected by means of a nipple 15, a quick opening valve 16 and a nipple 17 to a length of pipe 18 which is in turn coupled as indicated at 19 to the well casing 2. The pressure chamber 12 is preferably provided with a suitable indicating pressure gage 20 by which the pressure within the pressure chamber 12 may be readily measured. Thus for the production of the pressure wave all that is necessary

Defendant's Exhibit T—(Continued)

is to close valve 16, open valve 14 and allow pressure to be built up in the pressure chamber 12 to the desired pressure value, say, 600 pounds per square inch. Then the valve 14 is closed and valve 16 opened, allowing an impulse of 600 pounds per square inch to be injected into the well casing (the static pressure in which is, for exampe, 500 pounds per square inch.)

(∧F¹) ~~The pipe 18 is illustrated as being coupled~~ through a valve 21 to a diaphragm chamber 22, permitting a flexible diaphragm 23 to be placed into communication with the casing 2 whenever the valve 21 is opened. To control the sensitivity of response of the diaphragm 23 and in order to prevent undue distortion of the diaphragm 23 by the static pressure in the well and to avoid damage which would result therefrom, I prefer to allow the static pressure in the well casing 2 and pipe 18 to be equalized on both sides of the diaphragm 23 as by providing a by-pass 24 providing a restricted passage through which gas pressure in the chamber 22 on one side of the diaphragm may pass to the opposite side of the diaphragm, the filter 25 being interposed in the by-pass if desired to dry out the gas and prevent undue corrosion of the more delicate parts of the device contained in the diaphragm chamber 22. Attached to the diaphragm 23 is a mirror 26, preferably connected as shown in Fig. 5 upon a link 27, one end of which link is coupled by means of a rod 28 to the diaphragm 23. The opposite end of the link 27 is preferably connected

Defendant's Exhibit T—(Continued)

to one arm of a bellcrank lever 29, as indicated at 30. The bellcrank lever 29 is pivoted as at 31 to any desired portion of the metal comprising the diaphragm chamber 22, another arm of the bellcrank lever 29 extending as indicated at 32 to be engaged by an adjusting rod 33 so that by operating the adjusting rod 33 the fulcrum point 30 of the link 27 may be varied as desired to properly position chart the beam on a recording ~~charg~~.

In the front wall 34 of the diaphragm chamber 22 I mount a lens 35, through which light from a suitable light source 36 may pass into the chamber 22 to be reflected by the mirror 26, the reflected beam 37 passing back through the lens 35, as a ribbon beam which may be reflected or directed upon a ground glass screen 38 and upon a recording chart or strip of sensitized tape 39 to make a permanent record of the path described by the light beam 37. Suitable reflectors, such as indicated at 40, may be employed to direct the beam in any desired direction while a reflector 40a may be interposed in a portion of the ribbon beam 37 to direct a portion thereof upon the screen 38, suitable condenser lenses 40b and 40c being interposed ing the light beam 34 upon the recording tape 39, a the screen 38 and tape 39.

Thus as the pressure within the casing 2 is varied as by the pressure wave resulting from the pressure impulse created within the casing 1, the mirror 26 will be moved, the amplitude of its movement repre-

Defendant's Exhibit T—(Continued)

senting the amplitude of the pressure variation. As the echo of the pressure impulse from any obstruction within the well is received upon the diaphragm 23, the mirror 26 will be moved in accordance with the amplitude of the echo impulse and, will cause the echo impulses to be registered for observation, both by directing the light beam 37 upon the ground glass 38, where the amplitude of the echo may be visually observed and ~~while~~, by directin the light beam 34 upon the recording tape 39, a permanent record of the pressure wave which is created within the casing 2 may be made and this wave or chart will show peaks of varying amplitude, each of which peaks represents an echo from a particular obstruction within the well, either the tubing collars 10, the tubing catcher 9 or the fluid surface 6.

The sensitized strip 39 may be arranged to be driven at any desired speed by means of a variable speed motor 41 coupled to a suitable source of current 42 through a rheostat or other speed adjusting device 43 so that the tape or strip 39 may be driven at variable speeds.

By employing some device which will produce upon the record strip 39 a time lapse measurement, a direct comparison between the path described by the light beam and the lapse of time may be accomplished. I prefer to provide such mechanism including means for producing upon the strip 39 a series of dots or marks, each of which represents a

Defendant's Exhibit T—(Continued)

fraction of a second, the line of dots or marks extending substantially parallel to the general direction of the wave chart described by the light beam 37. This may be readily accomplished by providing a disc 44 having a plurality of openings 45 therein adapted to be rotated in the path of a secondary light beam 46 emanating from the light source 36. The light beam 46 passing through the openings of the disc 44 may be projected upon the same sensitized strip 39 to describe a series of marks thereon, one for each of the openings 45. One of the opens 45a is preferably larger than the remainder so that upon each revolution of the disc 44 a distinguishing mark will be produced. Thus by providing ten openings 45, a series of marks 48a may be produced upon the record strip 39 representing ten equal divisions. The tenth mark being produced by the large opening 45a is of greater length or of greater size or in some other manner distinct from the remaining nine marks. By providing the disc 44 with any suitable time mechanism such as a synchronous motor 47, the marks produced upon the charts will represent lapse of time; for example, each mark representing 1/10th of a second while the space between the distinct marks will represent lapses of one second each.

Due to the fact that the depth of wells varies considerably and, further, due to the fact that conditions of obstruction or constriction of the space between the well casing 2 and the tubing string 5

Defendant's Exhibit T—(Continued)

varies considerably in different wells, the same pressure differential cannot be used successfully in all wells and it is necessary to vary the pressure impulse through considerably wide limits, dependent upon the conditions encountered at a particular well. For this reason I prefer to direct a portion of the beam 37 upon the ground glass screen 38 so that by firing one charge of gas pressure into the well and observing the path described by the light beam, a determination of whether or not the correct pressure impulse is being used may be made. For example, one pressure impulse which is estimated to be correct for a given well may not produce a sufficient fluctuation in the echo waves received from the tubing catcher and the fluid surface, and a higher pressure or greater quantity of gas must be used in order to create the desired impulse. Thus by observing the effect of a succession of pressure impulses liberated into the well, the person making the survey will be able to determine which of the echoes rebounds from the tubing catcher and which of the echoes rebounds from the fluid surface.

The pressure wave velocity in different wells varying through wide limits, it is desirable to provide some regulation controlling the sensitivity of response of the diaphragm 23 to pressure variations and also to control the sensitivity of the diaphragm to distinguish between echoes from different obstructions in the well. In some surveys it may be desirable to render this diaphragm more

Defendant's Exhibit T—(Continued)

sensitive than in making surveys of other wells under other conditions, particularly for the purpose of allowing the amplitude of movement of the light beam in response to collar echoes to be substantially the same in the surveying of different wells, and I provide a ready means for varying the sensitivity of response of the diaphragm 23 by providing in the pressure chamber 22 two distinct chambers or compartments. One of these compartments or chambers 48 may be formed centrally of the diaphragm chamber 22 as by providing an annular division wall 49, the chamber 48 being disposed on the forward side of the diaphragm 23 and constituting a chamber of fixed volume. The second of these chambers 50 may be provided between the annular wall 49 and the exterior wall of the diaphragm chamber 22, the volume of this chamber being relatively great as compared with the volume of chamber 48. By providing an orifice 51 in the wall 49 intercommunicating chambers 48 and 50 and providing a valve 52 for regulating the effective size of this orifice, the effective volume of the chamber communicating with the forward face of the diaphragm 23 may be varied in small increments so that the diaphragm 23 may be so regulated as to respond with varying degrees of sensitivity.

The typical desired configuration of the path described by the light beam 37 is indicated in Fig. 2 wherein a represents the path described by the light beam as a result of the pressure wave created by

Defendant's Exhibit T—(Continued)

a discharge of gas from the chamber 12 into the well casing. From an inspection of the line a, it will be noted that this line is a relatively straight but somewhat wavy line, having distinct peaks at b, c and d. The peak b is that which will be produced by the deflection of the diaphragm 23 when the impulse of gas from the chamber 12 is liberated into the casing 2. At a predetermined time thereafter, dependent upon the velocity of the wave in the particular well, a peak c will be produced as a reflection from the tubing catcher 9, while at a predetermined time thereafter an additional peak or series of peaks will be produced at d as a reflection of the wave from the fluid surface.

Thus by observing the effects of a series of pressure impulses of different intensity or pressure, the operator may determine which impulse is most desirable to produce the distinctly recognizable and differentiatable peaks c and d, allowing him to differentiate between echo from the tubing catcher and the echo from the fluid surface. As hereinbefore stated, knowing the depth or location of the tubing catcher 9, the comparison of the elapsed time between the peaks b and c and the elapsed time between the peaks b and d, an accurate determination of the fluid level may be produced.

After the most desirable pressure impulse has been determined, the motor 41 may be set into action and a permanent record of the path described by the light beam may be made upon the sensitized film 39 with assurance that the various peaks b, c and

Defendant's Exhibit T—(Continued)

d will be readily distinguishable upon the diagram so produced.

As will be observed from an inspection of Fig. 2, the diagram on the strip 39 also shows the plurality of spaced dots or other means of indicating elapsed time, such series of dots being indicated at 48a.

Having made a diagram as indicated in Fig. 2, a direct measure and determination of the fluid depth may be achieved. Also it will be observed that by selecting impulses of the desired magnitude, reflections from other obstructions in the well may be noted and recorded, thus assisting in the location and determination of other restrictions as well as a measurement of the fluid level.

For example, each of the collars 10 of the tubing string will produce a distinct echo differentiatable from the echoes from other sources. This allows the accurate measurement of the fluid level in a well where, by reason of failure to keep records or loss of records, the location of the tubing catcher is not known or wherein the catcher is submerged or is omitted. For example, in some wells tubing has been drawn out and replaced by other tubing and no record has been made of the lengths of tubing drawn out or the lengths of each section drawn out or the lengths or number of tubing section employed to replace them so that to merely compare the time distance between the peaks b and c would not give a true indication of the velocity of the wave in the particular well. However, if it is reasonably assured that each of the tubing lengths is approximately the same, and the usual practice in oil wells

Defendant's Exhibit T—(Continued)

is to employ tubing lengths ^ in ~~of~~ a given well, all of which are the same, an indication of the number of tubing lengths located within any given well, multiplied by the average length of a tubing section, will give a true measure of the location of the tubing catcher or the location of the pump or other device which constitutes an obstruction in the well. Thus, for example, by selecting a desired pressure impulse, by comparison of a succession of pressure impulses and the waves produced thereby, upon the ground glass 38, a wave or line of the character indicated at a in Fig. 3 may be produced wherein, though a is still wavy, it is produced by a series of peaks e. By counting the number of these peaks, each of which represents a reflection back from a collar 10, the number of lengths of tubing between the peaks b, c and d may be determined.

However, in actual practice there are so many other possible disturbances in the well as to create peaks similar to e which are not readily distinguishable therefrom and I prefer to provide a means for tuning out other vibrations, harmonics or other disturbances so that the peaks e will accurately represent only reflections from the collars 10.

As will be understood, the introduction into a sound wave or multiplicity of sound waves of another wave tuned with one of the waves, produces a beat or amplification of certain of these waves

Defendant's Exhibit T—(Continued)

differing in frequency from the first wave will be damped out. By selecting the correct length for the pipe 18, that is, by selecting the correct distance between the casing 2 and the diaphragm 23, a tuned wave may be produced which will effect the movements of the diaphragm 23. Since it is desired to count the number of tubing collars, all that is necessary is to lengthen or shorten the pipe 18 until it is tuned to one of the harmonics of the impulses or echoes produced by the collars 10. From experience it has been found that selection of the pipe 18 of approximately one-third of the length of a section or joint of the tubing 5, a third harmonic is produced which beats with the impulses echoed from the tube collars 10 to produce magnified or amplified peaks e and permits the ready distinguishing of the impulses produced by the collars 10 from other impulses.

I prefer, however, to employ in the length of the pipe 18 an adjustable coupling 19 which allows the accurate lengthening or shortening of the pipe 18 until, by observing the path of the light beam upon the ground glass 38, a distinct pattern is made represented by the line a on Fig. 4, in which each of the intermediate peaks e is amplified as indicated in Fig. 4 so that it is readily recognizable.

The adjustment of the coupling 19 should be made until, with a given pressure impulse, a uniform deflection of the mirror 26, that is, a uniform amplitude of the peaks e, is achieved, and by observing

Defendant's Exhibit T—(Continued)

this upon the ground glass 38 the operator will note when the pipe 18 is of such length as to be "tuned" with the tubing lengths.

Thus, even though the location of the tubing catcher is not known, if the average length of tubing section is known, the production upon the strip 39 of a diagram such as shown in Fig. 4 allows the counting of each of the collars 10 and a clear understandable record is made of the length of tubing string between the impulses b, c and d, permitting the quick and accurate location and determination of the exact level of the fluid in the well.

Where the tubing lengths are not known and where the location of the tubing catcher is not known, or where the catcher and liner top are submerged, a quick and ready method of determining the velocity of the pressure wave through the particular gaseous medium encountered in a particular well may be made by employing an elongated tube or pipe 53 coupled as by means of a short pipe 54 to the pipe 18 and controlled by a valve 55 in such manner as to permit gas from the casing 1 to flow through the pipe or tube 53, thus providing in the pipe 53 an atmosphere corresponding to the atmosphere or gaseous medium in the casing 1. An open exhaust pipe 56 leads from the opposite end of pipe 53 open to the atmosphere or connected to a gas flow line so that the pressure within the pipe or tube 53 will remain substantially constant as of the value of the gas in the casing 1. Near one end of the tube 53, a diaphragm 57 may be provided

Defendant's Exhibit T—(Continued)

and arranged to be vibrated at any desired frequency as by coupling the diaphragm 57 by a pipe 58 open to the atmosphere at 58a, to a source of fluid pressure, such as compressed air, indicated at 59. A rotary valve 60 is interposed in the pipe 58 and arranged to be driven by means of a variable speed motor 61 regulated as to speed by means of a variable speed motor 61 regulated as to speed by means of a suitable rheostat or other controlling device 62 so that by rotating the motor 61 at any speed a series of pressure impulses will be created in the pipe 58, and will beat upon diaphragm 57 to create a pressure wave in the tube or pipe 53 of known frequency, the frequency being variable by varying the speed of motor 61.

At the opposite end of the pipe 53 I couple a pressure responsive device which may be constructed in the same manner as the diaphragm chamber 22 and diaphragm 23 hereinbefore described. This pressure responsive device is illustrated at 63 coupled directly to the end of the pipe 53, the diaphragm 64 of which receives the impulses transmitted through the pipe 53 to vibrate in response thereto and to move a mirror 65 in the same manner as was described with reference to the mirror 26. The mirror 65 reflects a light beam from a suitable source 66 upon a polygon of mirrors 67 revolved by means of an adjustable speed motor 67a at a speed synchronous with the speed of the motor 61 so that the amplitude and uniformity of

Defendant's Exhibit T—(Continued)

the vibrations of the diaphragm 64 may be visibly observed.

As is well known in the art, each gaseous medium, variable as to density, temperature, etc., is resonant to pressure waves or sound waves of predetermined frequency. Thus by varying the speed of operation of the motor 61 until the pressure impulse created by the diaphragm 57 makes one round ∧ ~~stip~~ trip (or multiple thereof) to the diaphragm 64 and back to the diaphragm 57 in time to just synchronize with the next impulse created by the diaphragm 57, the pattern described by the beam of light on the mirrors 67 will show uniform amplitude, and noting the frequency of the impulses produced upon the diaphragm 57 (that is, noting the speed of the motor 61) the velocity of the sound through this particular gaseous medium may be readily determined by comparing this frequency with the frequency at which resonance is achieved at the pipe 53 with air in it.

It will therefore be observed that I have provided a method of determining the location of obstructions in wells and accurately locating and measuring the fluid level in a well without the necessity of removing any of the apparatus from the well, the entire measurement and determination being accomplished in a relatively short time.

It will be understood by those skilled in the art that the creation of pressure impulses within the well may be accomplished by decreasing the pres-

Defendant's Exhibit T—(Continued)

sure in the well instead of admitting a charge of gas from the pressure tube 12 into the well. For example, if the pressure in the well is relatively high, the valve 14 in the pressure chamber may be closed and the valve 16 opened, allowing the pressure in the well to build up within the impulse chamber 12. Then by operating valve 14, allowing the pressure within the chamber 12 to rapidly discharge, a pressure impulse may be created within the well which acts in the same manner as hereinbefore described for the introduction of pressure from the tank or other source 11.

It will also be understood that if desired special constrictions may be placed in the well for future measurements of the fluid level therein to take the place of the tubing catcher 9. Such constrictions could comprise a closed cylinder of pipe surrounding and attached to one of the tubing sections when the tubing is run into the well and by noting and recording the location of such constriction, the future measurements of the fluid level by my pressure impulse method can be readily determined, employing the reflection of the wave from the restricting member in place of the reflection from a tubing catcher 9 or other restriction in the well.

While I have shown and described the preferred embodiment of my invention, I do not desire to be limited to any of the details of construction shown

Defendant's Exhibit T—(Continued)

or described herein, except as defined in the appended claims.

I Claim:

~~1. The method of determining the location of~~ obstructions in wells which consists in creating a pressure impulse in the well, the amplitude of which impulse is variably selected dependent upon the depth of the well and the resistance to wave transmission in the well, to cause an echo thereof from the obstruction to arrive at some predetermined point with sufficient energy to be readily detected and translated, and measuring the lapse of time between the creation of said impulse and the arrival of the echo at said pre-determined point.

2. The method of determining the location of obstructions in wells which consists in creating in the well a pressure impulse the amplitude of which is selected proportional to the depth of the well and inversely proportional to the unrestricted cross sectional area of the well to cause an echo thereof from the obstruction to arrive at the ground surface with sufficient energy to be readily detected and translated, and measuring the lapse of time between the creation of the impulse and the arrival of the echo at a predetermined point.

3. The method of determining the location of obstructions in wells which consists in creating in the well a pressure impulse the amplitude of which is selected proportional to the depth of the well, ~~proportional to the gas pressure in the well and in~~

Defendant's Exhibit T—(Continued)

versely proportional to the unrestricted cross sectional area of the well to cause an echo thereof from the obstruction to arrive at the ground surface with sufficient energy to be readily detected and translated, and measuring the lapse of time between the creation of the impulse and the arrival of the echo at a predetermined point.

4. The method of measuring the location of obstructions in wells having a casing and oil flow tubing therein, which consists in creating within the casing a pressure impulse the amplitude of which is proportional to the depth of the well and inversely proportional to the annular space between the tubing and the casing to cause an echo thereof from the obstruction to arrive at the ground surface with sufficient energy to be readily detected and translated, and measuring the lapse of time between the production of the impulse and the arrival of the echo at the ground surface.

5. The method of determining the location of obstructions in wells, which consists of creating in the well a series of pressure impulses, each of different amplitude, until the echoes thereof from different obstructions in the well are readily distinguishable from each other, and then measuring the lapsed time between the creation of the impulse and the arrival of each of the distinguishable echoes at a predetermined point relative to the well.

6. The method of determining the location of obstructions in wells, which consists in creating in the well a series of pressure impulses, each of dif-

Defendant's Exhibit T—(Continued)

ferent amplitude, until the echoes thereof from different obstructions in the well are readily distinguishable from each other, and then measuring the lapsed time between the creation of the impulse and the arrival of each of the distinguishable echoes at the ground surface.

7. The method of determining the unknown location of an obstruction in a well having another obstruction at a known location, which consists in creating in the well a pressure impulse, measuring the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction, and measuring the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

8. The method of determining the unknown location of an obstruction in a well containing a gaseous medium and having another obstruction at a known location therein, which consists in measuring the velocity of pressure waves through the well under measurement, creating a pressure impulse in the well and noting the lapse of time between the creation of the impulse and the arrival at a predetermined point in the well of the echo from the unknown obstruction.

9. The method of determining the unknown location of an obstruction in a well containing a gaseous medium and having an obstruction at a known location therein, which consists in creating a pressure impulse in the well, noting the elapsed

Defendant's Exhibit T—(Continued)

time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction to determine the velocity of the pressure wave through the well under measurement, and noting the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

10. The method of determining the unknown location of an obstruction in a well containing a gaseous medium and having an obstruction at a known location therein, which consists in creating a pressure impulse in the well at the ground surface, noting the lapse of time between the creation of the impulse and the arrival at the ground surface of an echo from the known obstruction to thereby determine the velocity of the pressure wave through the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at the ground surface of the echo from the unknown obstruction.

11. The method of determining the unknown location of an obstruction in a well having a casing, tubing and tubing catcher or liner top therein, which consists in the creation at the ground surface of a pressure impulse within the casing, noting the lapse of time between the creation of the pressure impulse and the arrival at the ground surface of an echo from the tubing catcher or liner top whereby the velocity of pressure waves through

Defendant's Exhibit T—(Continued)

the particular well under measurement may be determined, and noting the lapse of time between the creation of the impulse and the arrival at the ground surface of the echo from the unknown obstruction, the location of the unknown obstruction calculated from the lapsed time between the creation of the pressure impulse and the arrival of the echo from the unknown obstruction.

12. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating a pressure impulse in the well, noting the echoes thereof from portions of the tubing string to determine the velocity of the pressure wave through the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.

13. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately the same length, which consists in creating a pressure impulse in the well, noting the frequency of the echoes from the couplings of the tubing sections to determine the velocity of the pressure wave in the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.

Defendant's Exhibit T—(Continued)

14. The method of determining the unknown location of an obstruction in a well, which consists in locating another obstruction in the well at a known depth in the well, creating a pressure impulse in the well, noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo thereof from the obstruction of known location, and noting the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.

15. The method of determining the location of an obstruction in a well containing a gaseous medium, which consists in passing the gaseous medium from the well through a pipe of predetermined length, creating in said pipe pressure impulses to produce therein a pressure wave, varying the frequency of said impulses until resonance of the wave in said pipe and in said gaseous medium is achieved, comparing said frequency with the resonant frequency of said pipe when filled with air to determine the velocity of pressure waves through the particular well under measurement, and then creating a pressure impulse in said well, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo thereof from the unknown obstruction.

16. The method of determining the location of an obstruction in a well containing a gaseous me-

Defendant's Exhibit T—(Continued)

sections interconnected by coupling collars
dium and having located therein a string of tubing ∧ ~~located therein,~~ which consists in coupling a pressure responsive device to the well, creating a pres-
adjusting the length of
sure impulse in the well, ∧ ~~lengthening or shortening~~ the coupling between the well and the pressure
pressure responsive device
responsive device until the ∧ ~~coupling~~ is tuned to one of the harmonics of the echoes of the pressure
collars
impulse from successive ∧ ~~couplings~~ in the tubing string, noting the frequency of the echoes from the collars of the tubing string to determine the velocity of pressure waves through the particular well under measurement, and measuring the lapsed time between the creation of a pressure impulse in the well and the arrival at a predetermined point of the echo from the obstruction.

17. The method of determining the location of an obstruction in a well, which consists in introducing a pressure impulse into the well, coupling a pressure responsive device to the well, and visually indicating the movements of said pressure responsive device under the influence of echoes of the pressure impulse.

18. The method of determining the location of an obstruction in a well, which consists in introducing a pressure impulse into the well, coupling a pressure responsive device to the well, visually indicating the movements of said pressure responsive device under the influence of echoes of the pressure impulse, and

Defendant's Exhibit T—(Continued)

drawing a graph of said movements related to time lapse between successive movements.

19. The method of determining the location of an obstruction in a well, which consists in creating a series of pressure impulses in the well, coupling a pressure responsive device to the well, visually indicating the movements of the pressure responsive device under the influence of echoes received from obstructions in the well, varying the amplitude of successive pressure impulses until the indication of the echo from the obstruction to be measured is clearly visually distinguishable from other pressure vibrations, and measuring the lapse of time between the creation of the impulse of the selected magnitude and the response of the pressure responsive device to the echo from said obstruction.

20. In an apparatus for determining the location of an obstruction in a well, means for creating pressure impulses in the well of variable amplitude, and means for measuring the lapse of time between the creation of any of the impulses and the arrival at a predetermined point of the echo of said impulse from said obstruction.

21. In an apparatus for determining the location of an obstruction in a well, means for creating pressure impulses in the well of variable amplitude, a pressure responsive device movable in response to pressure impulses applied thereto, the amplitude of the movement varying in accordance with the amplitude of the impulse received, means for visually observing the movements of said pressure responsive

Defendant's Exhibit T—(Continued)

device, and means for measuring the lapse of time between the creation of any of the impulses and the arrival at a predetermined point of the echo of said impulse.

22. In an apparatus for determining the location of an obstruction in a well, means for creating pressure impulses in the well of variable amplitude, a pressure responsive device movable in response to pressure impulses applied thereto, the amplitude of the movement varying in accordance with the amplitude of the impulse received, light reflecting means associated with said pressure responsive device, means for directing a light beam upon said reflecting means, and means for receiving the reflected beam including both a screen for visually observing the movement of the reflected light beam, and a light sensitive recording means for making a permanent record of the movement of said reflected beam.

23. In an apparatus for determining the location of an obstruction in a well, means for creating a pressure impulse in the well, a pressure responsive device movable in response to pressure impulses applied thereto, the amplitude of the movement varying in accordance with the amplitude of the impulse received, light reflecting means associated with said pressure responsive device, means for directing a light beam upon said reflecting means, and means for receiving the reflected beam including both a screen for visually observing the movement of the ~~reflected light beam, and a light sensitive recording~~

Defendant's Exhibit T—(Continued)

~~mean for making a permanent record of the movement of said reflected beam.~~

2 ~~24~~. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a pipe coupling said pressure responsive device to the well, adjusting the ~~length of~~ effective length of means for ∧ ~~lengthening or shortening~~ said pipe to pressure responsive device tune said ∧ ~~pipe~~ to one of the harmonics of echoes of said impulse received from the coupling collars of said tubing string, and means for measuring the frequency of said tubing collar echoes and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of said impulse from said obstruction.

3 ~~25~~. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a pipe coupling said pressure responsive device to the well, adjusting the ~~length of~~ effective length of means for ∧ ~~lengthening or shortening~~ said pipe to pressure responsive device tune said ∧ ~~pipe~~ to one of the harmonics of echoes of said impulse received from the coupling collars.

Defendant's Exhibit T—(Continued)

of said tubing string, and means associated with said pressure responsive device for measuring the frequency of said tubing collar echoes and for counting the same and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of said impulse from said obstruction.

4 ~~26~~. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, a ^ ~~pipe~~ means intercoupling with ~~coupling~~ said pressure responsive device ^ ~~to~~ the well and having such effective length as to tune said pressure responsive device ^ ~~pipe~~ to one of the harmonics of echoes of said impulses received from the coupling collars of said tubing string, and means associated with said pressure responsive device for measuring the frequency of said tubing collar echoes and for couting the same and for measuring the lapse of time between the creation of said impulse and the arrival at the pressure responsive device of the echo of the impulse from said obstruction.

~~27. In an apparatus for determining the location of an obstruction in a well, means for creating a pressure impulse in the well, a pressure responsive device including diaphragm means, means coupling said diaphragm means to said well to allow the pres-~~

Defendant's Exhibit T—(Continued)

~~sure of said well to press upon said diaphragm~~ means whereby said diaphragm means will move in accordance with variation in pressure within said well, and means for measuring the lapse of time between the creation of said pressure impulse and the movement of said diaphragm means by the echo ~~of said impulse from said obstruction~~.

5 ~~28~~. In an apparatus for determinig the location of an obstruction in a well, means communicating with said well for creating a pressure impulse in the well, a pressure responsive device including diaphragm means, means coupling said diaphragm means to said well to allow the pressure of said well to press upon one face of said diaphragm means, means communicating between said coupling means and the opposite face of said diaphragm means for equalizing the static pressure on both sides of said diaphragm means whereby said diaphragm means will move in accordance with variation in pressure within said well, and means for measuring the lapse of time between the creation of said pressure impulse and the movement of said diaphragm means by the echo of said impulse from said obstruction.

6 ~~29~~. In an apparatus for determining the location of an obstruction in a well, means communicating with said well for creating a pressure impulse in the well, a pressure responsive device including diaphragm means, means coupling said diaphragm means to said well to allow the pressure of said well to press upon one face of said diaphragm means, means defining a restricted by-pass intercommuni-

Defendant's Exhibit T—(Continued)

cating the opposite face of said diaphragm means with said coupling means to equalize the static pressure on both faces of said diaphragm means whereby said diaphragm means will move in accordance with variation in pressure within said well, and means for measuring the lapse of time between the creation of said pressure impulse and the movement of said diaphragm means by the echo of said impulse from said obstruction.

7 ~~30~~. In a device for determining the location of an obstruction in a well, means communicating with said well for creating a pressure impulse in said well, means for receiving and translating echoes received from said obstruction including diaphragm means, coupling means intercommunicating one face of said diaphragm means with said well, means defining a pressure equalizing chamber on the opposite face of said diaphragm, means defining a second chamber of greater volume communicating with said first chamber, valve means for restricting communication between said two chambers to vary the effective volume of the chamber exposed to said opposite face of said diaphragm means to control the sensitivity of response of said diaphragm means to pressure variation in said well, and means for measuring the lapse of time between the creation of said impulse and the movement of said diaphragm by the echo of said impulse from said obstruction.

~~31. In a device for measuring pressure fluctuations, a pressure responsive device movable in response to pressure impulses applied thereto, the am-~~

Defendant's Exhibit T—(Continued)

plitude of the movement varying in accordance with the amplitude of the impulse received, light reflecting means associated with said pressure responsive device, means for directing a light beam upon said reflecting means, and means for receiving and translating the reflected beam.

32. In a device for measuring pressure fluctuations, a pressure responsive device movable in response to pressure impulses applied thereto, the amplitude of the movement varying in accordance with the amplitude of the impulse received, light reflecting means associated with said pressure responsive device, means for directing a light beam upon said reflecting means, and means for receiving and recording the path described by said light beam, said recording means including a movable tape, means for directing the light beam upon said tape, means for moving said tape past said light beam receiving means at a predetermined rate of speed, means for producing upon said tape a time lapse record extending substantially parallel to the record produced by said beam, said time record including markings denoting lapses of units of time and distinguishable markings denoting lapses of multiples of said units.

33. The method of determining the velocity of pressure waves in a given medium, which consists in passing said medium through an elongated tube, producing in said tube pressure waves of known frequency, varying said frequency until resonance of the pressure waves is achieved, and comparing the

Defendant's Exhibit T—(Continued)

resonance frequency with the resonance frequency in said tube in air.

34. In an apparatus for determining pressure wave velocity in a given medium, an elongated tube, means communicating with said tube for passing the said medium through said tube, means associated with said tube for creating pressure waves in said tube of known frequency, means associated with said pressure wave creating means for varying said frequency, and means communicating with said tube for determining when the frequency is such as to resonate in the medium in the tube.

35. In an apparatus for determining pressure wave velocity in a given medium, an elongated tube, means communicating with said tube for passing the said medium through said tube, means associated with said tube for creating pressure waves in said tube of known frequency, means associated with said pressure wave creating means for varying said frequency, and means communicating with said tube for observing pressure fluctuations in said tube to determine resonance of the waves in said medium.

36. In an apparatus for determining pressure wave velocity in a given medium, an elongated tube, means communicating with said tube for passing the said medium through said tube, means associated with said tube for creating pressure waves in said tube of known frequency, means associated with said pressure wave creating means for varying said frequency, diaphragm means communicating with said tube for movement under the influence of pressure

Defendant's Exhibit T—(Continued)

~~variations in said tube, a source of light, means~~ associated with said diaphragm for directing a light beam from said source upon a screen whereby observing the form and amplitude of movement of said light beam on said screen resonance of said frequency in said medium may be observed.

37. A method and means for measuring the location of obstructions in wells substantially as shown ~~and described.~~

In Testimony Whereof I affix my Signature
(Sign here first name in full)
CRANFORD P. WALKER.

OATH

State of California
County of Los Angeles—ss.

Cranford P. Walker, the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of San Marino, California; that he verily believes himself to be the original, first and sole inventor or discoverer of the Method and Means for Measuring the Location of Obstructions in Wells described and claimed in the annexed specifications; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this applica-

Defendant's Exhibit T—(Continued)

tion; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said invention has been filed by him or his legal representatives or assigns in any country foreign to the United States.

(Sign here first name in full)

CRANFORD P. WALKER

Subscribed and sworn to before me, this 31st day of August, 1937.

(Seal) MARJORIE McKAY

Notary Public in and for the said County and State

My Commission Expires July 14, 1941

Plans of drawings in originality file.

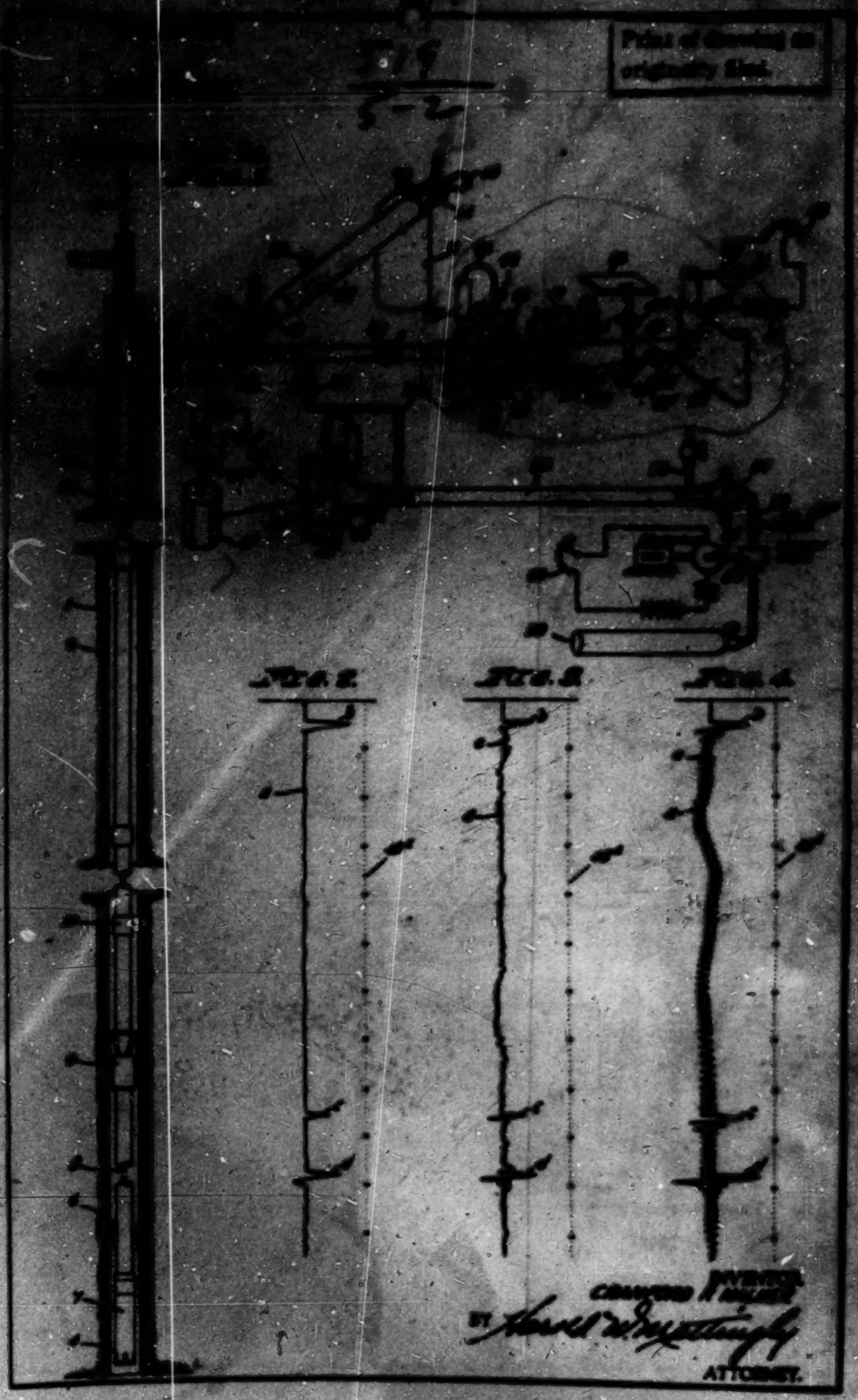


FIG. 2.

FIG. 3.

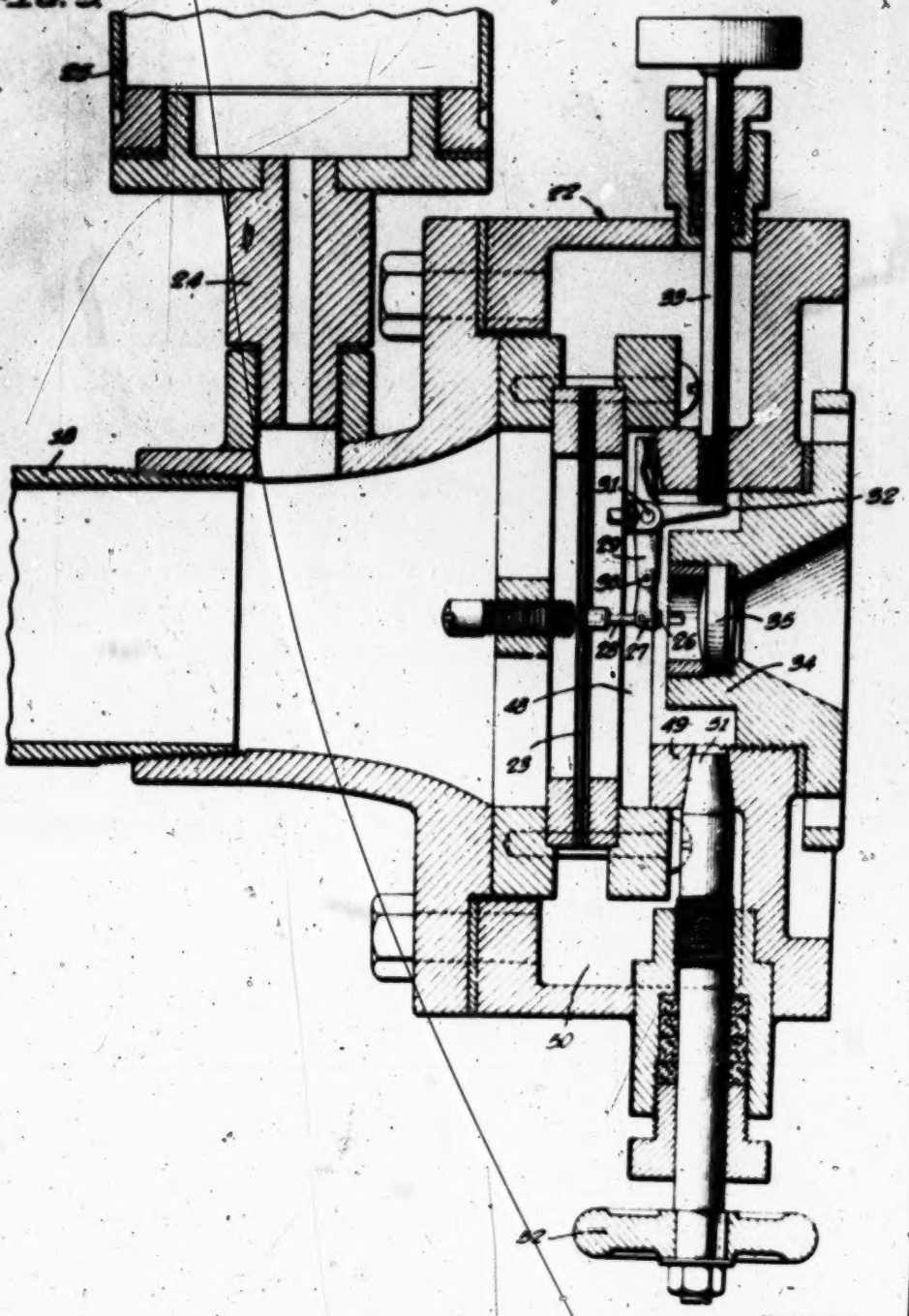
FIG. 4.

INVENTOR
CRAWFORD HILLIS
BY Howard W. Hopkins
ATTORNEY.

162699 46 181-0.5

Print of drawing as originally filed.

FIG. 5.



INVENTOR
CRANFORD P. WALKER
BY Harold W. Mellingly
ATTORNEY

Defendant's Exhibit T—(Continued)

260

Div. 5 Room 3077.

Department of Commerce
United States Patent Office
Washington

Paper No. 3

All communications respecting this application should give the serial number, date of filing, and name of the applicant

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

CLJ/H

Oct. 25, 1937

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE
Commissioner of Patents.

Defendant's Exhibit T—(Continued)

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope St.
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 162,699
Filed Sept. 7, 1937
For Method and Means for Measuring the Location of Obstructions in Wells

Mailed Oct 25 1937.

References made of record:

Batcheller	602,422	Apr. 19, 1898	181-0.5
Taylor	1,847,636	Mar. 1, 1932	274-5 x-r

Page 13, line 11, should not "charg" be chart?

Page 24, line 10, should not "stip" be trip?

Claims 1 to 13, 17 to 21 and 24 to 27 are rejected as being unpatentable over Batcheller, who shows it to be old to create an impulse in a well to travel down until an obstruction is reached, and to return as an echo to energize a recorder from which an indication may be had as to the depth of the obstruction below the surface.

Claims 14 to 16, 28 to 30 and 33 to 36 are deemed to be allowable.

Claims 22, 23, 31 and 32 are rejected as being unpatentable over Batcheller above cited, who shows a means of recording the pressure wave in a well, in view of Taylor, who shows a recording device for recording sound waves embodying the same struc-

Defendant's Exhibit T—(Continued)

ture as is utilized by applicant. No invention is seen to be required to substitute the recording device of Taylor for the recorder of Batcheller.

Claim 37 is rejected as not meeting the requirements of Section 4888, Revised Statutes.

C. W. ROBINSON,
Examiner.

Mail Division Apr 21 1938 U. S. Patent Office.
Received Apr 23 1938 Division 5, Paper No. 4
Amendment A.

In the United States Patent Office
Division 5 — Room 3077

Cranford P. Walker,
Method and Means for Measuring the Location of Obstructions in Wells,

Filed September 7, 1937,
Serial No. 162,699.

Los Angeles, California,
April 19, 1938.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

In response to the Office action of October 25, 1937, please amend the above identified application as follows:

Page 13, Line 11, change "charg" to read —chart—.

Page 24, Line 10, change "stip" to read —trip—.

Defendant's Exhibit T—(Continued)

Cancel Claims 17, 18, 27, 31, 32 and 37 and add the following claims:

A[1]

8 ~~38~~. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of the diaphragm to the medium, a by-pass extending between the compartments to equalize the static pressure of the medium on opposite faces of the diaphragm, light-reflecting means associated with the diaphragm, means for directing a light beam upon said reflecting means to reflect the beam through said window, and means disposed exteriorly of said housing for receiving and translating the reflected beam.

9 —~~39~~. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of

Defendant's Exhibit T—(Continued)

the diaphragm to the medium, a by-pass extending between the compartments to equalize the static pressure of the medium on opposite faces of the diaphragm, light-reflecting means associated with the diaphragm, means disposed exteriorly of the housing for directing a light beam through said window to strike said reflecting means and to be reflected thereby back through said window, and means disposed exteriorly of said housing for receiving and translating the reflected beam.—

REMARKS

Reconsideration of Claims 1 through 6 is respectfully requested. The Examiner rejected each of these claims as unpatentable over the patent to Batcheller. It is believed that in making this rejection of Claims 1 through 6 the Examiner has overlooked the important limitation in each of these claims to the effect that the amplitude of the impulse which is produced in the well is variable or variably selected in such manner as to produce a wave pattern in which various obstructions or restrictions in the well may be clearly distinguished from each other, as for example the tubing collars will produce a distinct wave pattern, the tubing catcher will produce a different wave pattern, the fluid level will produce a still different wave pattern, perforations in the casing or in the screen liner will produce a different pattern, the top of the screen liner will produce a different pattern, while other enlargements or constructions of the diameter of the well

Defendant's Exhibit T—(Continued)

casing or bore will produce such distinctive wave patterns that each of these may be detected upon the record and clearly recognized both as to their character and as to their location. This is possible to accomplish only if the proper amplitude or magnitude of pressure impulse is created in the well and the magnitude of the impulse must be capable of being changed, either increased or decreased until the wave pattern produced by echoes from the different obstructions are capable of being distinguished from each other.

The mere creation of a pressure impulse of arbitrarily selected magnitude, as is disclosed in Batcheller, may produce a result of obtaining a reflection from one obstruction in the well which can be detected and located thereby but only provided the impulse obtained by the shot is by remote chance and accident so coordinated with the gas pressures existing in the well and the depth of the obstruction from the ground surface that the echo can be received and detected at the surface. In other words, utilizing the method and apparatus disclosed in Batcheller leaves the results entirely up to chance.

Not until the applicant devised his method and apparatus for producing impulses of varying magnitude was it possible to measure, locate and distinguish various obstructions in the well by the sound or pressure wave method. Previous to his discovery that there was a direct relation between the magnitude of the impulse, the gas pressures in the well,

Defendant's Exhibit T—(Continued)

the amount of restriction or resistance to the passage of the impulse through the well and the depth of a particular obstruction or restriction sought to be measured, many attempts were made to use the pressure echo principle to locate and distinguish obstructions in wells with only indifferent and intermittent success. The reasons for the failure were not known and because of such failures the Batcheller method was not considered to be commercially practicable. It was only after the applicant discovered the relation between all of these factors and had determined that a pressure impulse which would produce results in one well would produce no useable results in another well that commercial applications of the pressure echo principle were made possible.

The use of pressure impulses of varying magnitude is an important improvement over anything which is disclosed in the Batcheller patent since it is the difference between success and failure. By employing the applicant's method of using an impulse of one magnitude, checking the results, then using the impulse of another magnitude and checking the results until the correct impulse is determined, and then making the measurement, the resultant graph will clearly and readily distinguish the location of the particular obstruction which may be readily and accurately determined and distinguished from any other obstructions that may exist in the well or by estimating the probable location of the unknown obstruction, estimating, measuring or computing the gas pressure and the known restrictions in the path

Defendant's Exhibit T—(Continued)

of the impulse and echo, an impulse of the correct magnitude may be selected with assurance of useful results.

Attached hereto is a copy of an actual graph made upon a well by the applicant's method as outlined in Claims 1 through 6. In testing this will several different impulses were tried and their effects were observed upon the screen 38 until the operator observed that each of the elements in the wave pattern was distinguishable from each other. Then another impulse of this same magnitude was used and the graph was made, in which can be readily distinguished each of the tubing collars between the points X and Y, the tubing catcher at a depth of 1850 feet, the liner top at a depth of 1930 feet, the location of perforations in the casing or liner below the liner top and the location of the fluid level at the point indicated at Z where the wave pattern tends to smooth out into a smooth curve. Such wave pattern with each of the obstructions clearly distinguishing from the others could not be produced by the Batcheller method but only by the applicant's method in which a series of impulses are used to determine which of them is the best or in which after suitable calculation a predetermined impulse is selected to produce the desired result.

It is therefore clear that the limitation of variably selecting the amplitude of the impulse as specified in Claims 1, 5 and 6, or initially selecting the amplitude of the impulse to conform with gas pressure, restrictions and depth of the well as specified in

Defendant's Exhibit T—(Continued)

Claims 2, 3 and 4, constitutes an improvement over the method disclosed in Batcheller, which improvement advances this art and is therefore patentable.

Reconsideration of Claims 7 through 12 is respectfully requested, each of these claims being directed to a method which includes steps not disclosed in Batcheller, namely, the method of determining the location of an unknown obstruction by comparing the lapse of time for the echo from the unknown obstruction to reach the ground surface with the lapse of time required for the echo from a known obstruction to reach the ground surface. Each of these claims is directed to the feature that the velocity of the echo will be different for every well and that one way in which to make an accurate determination of the location of an unknown obstruction is to first determine the velocity of the echo waves in the particular well under consideration by employing some obstruction at known depth to compare the lapse of time for the travel of the echo from the unknown obstruction. There is no teaching of this method or these steps in the Batcheller disclosure and in the absence of a reference showing these steps these claims must be allowed.

Reconsideration of Claim 13 is respectfully requested, this claim having to do with the comparison of the frequency of the echoes from the tubing collars as a means for determining the velocity of the pressure wave in a particular well and utilizing the velocity value so determined to determine the location of the unknown obstruction. Again there is no

Defendant's Exhibit T—(Continued)

such teaching in the Batcheller patent and this claim is clearly allowable over the Batcheller patent.

Reconstruction of Claim 19 is respectfully requested, this claim having to do with the method which consists in producing a series of pressure impulses in the well, varying the amplitude of the successive impulses, and observing the effects of the different impulses until the echoes from the unknown obstruction are clearly distinguishable from other vibrations which may be disregarded or echoes from other obstructions which are at known locations or observation of which is not necessary. Again the use of variable impulses is not shown in Batcheller nor is the observation of the effects of different impulses shown in Batcheller and this claim is clearly allowable over the reference.

Reconsideration of Claim 20 is respectfully requested for the same reasons as set forth with reference to Claims 1 through 6, this claim being directed to the apparatus for determining the location of an obstruction in a well which includes "means for creating pressure impulses in the well of variable amplitude" which is a feature not shown in the Batcheller patent and without which the Batcheller patent is either totally unsuccessful or produces such unreliable results as to render it substantially without utility. As set forth with reference to Claims 1 through 6, it is the applicant's ability to produce a series of impulses of variable magnitude which permits him to select the impulse of proper magnitude to obtain a resultant graph

Defendant's Exhibit T—(Continued)

in which the particular obstruction sought to be located may be clearly distinguished from other obstructions which are either known or the location of which is not particularly desired. Unless the Examiner can find a reference which shows that this important improvement step was known and which discloses mechanism by which this improvement can be obtained, this claim, like Claims 1 through 6, must be allowed.

Reconsideration of Claims 21, 22 and 23 is respectfully requested for the reason that each of these claims includes the means for producing the impulse of "variable magnitude" and also the means by which the effects of the different impulses may be visually observed so that an operator can create a succession of impulses of variable magnitude, visually observe their results until he knows that an impulse of the proper magnitude has been found, and then he may produce the graph or may otherwise measure the time lapse between the creation of the impulse and the return of the echo from a particular obstruction he seeks to determine. This is more than the mere shooting of a pistol into a well and watching a pressure indicator such as that shown in Batcheller; instead, it involves a step of the method and mechanism which permits the production of this step, neither of which is shown or suggested by Batcheller.

As expressed in Claim 21, this observance and selection of the correct impulse may be accomplished with any mechanism which will permit vis-

Defendant's Exhibit T—(Continued)

ual observation of the effects of the impulse while in Claims 22 and 23 this means for making the observation and selection is defined as a light beam means, which lends itself peculiarly by reason of the ease with which the various echoes may be distinguished from each other on the screen and the fidelity with which the light beam may follow the variations in the pressures resulting from the echoes. It would therefore require invention to adapt the Batcheller disclosure to produce the results set forth in these claims and Batcheller therefore fails as a basic reference for the reason that it fails to show the complete combination for producing the result, one essential element being missing, namely, the means for creating impulses of variable magnitude. Batcheller failing as a basic reference, it is then not proper for the Examiner to combine with the faulty Batcheller disclose a disclosure of a light beam translation mechanism to the structure of Batcheller and to hold that there would be no invention in such combination. Even though it were true that it would not require invention to substitute the Taylor translation mechanism for the mechanical mechanism of Batcheller (and applicant does not admit this) the combination of these references would still fail to meet the invention expressed in these claims.

Reconsideration of Claims 24 and 25 is respectfully requested, each of these claims defining an important feature of the applicant's device which is not found in Batcheller, namely, the ability to

Defendant's Exhibit T—(Continued)

tune the instrument to the echoes received from a succession of tubing collars to thereby permit the applicant to count the tubing collars by the echoes from the tubing collars. This is illustrated particularly in Fig. 4, showing the result of the tuning of the translation mechanism with one of the harmonics of the echoes from the tubing collars. With the graph shown in Fig 2 it would be impossible to count the tubing collars while tuning the translation device to the echoes or one of the harmonics of the echoes from the tubing collars produces a graph as shown in Fig. 4 in which the record of each of the tubing collars is clearly apparent and distinguishable from other echoes received from other obstructions. The Examiner's attention is called to the actual graph made by the applicant's method and apparatus in which it is seen that each of the tubing collar echoes may be clearly distinguished so that they may be counted for the purposes set forth on Pages 19 and 20 of the specification, and the ability to produce such a graph constitutes an important contribution by the applicant to this art. To merely fire a shot into a well and observe such echoes as may be reflected back in accordance with the Batcheller method and apparatus would not produce this result and hence each of these claims clearly defines patentable subject matter.

Reconsideration of Claim 26 is also respectfully requested for the same reasons as set forth with

Defendant's Exhibit T—(Continued)

reference to Claims 24 and 25. In Claim 26 the length of the coupling between the pressure responsive device and the well is selected such that it is tuned to the harmonics of the echoes from the tubing collars, the result being a new and valuable result impossible to obtain with the Batcheller method or device. The applicant has found that in many instances it is possible, knowing the length of the tubing collars, to previously select a length of pipe to couple the pressure responsive instrument to the well in such manner as to "pre-tune" the instrument to the harmonics of the tubing collar echoes and is clearly entitled to protection upon this feature as expressed in Claim 26.

Reconsideration of new Claims 38 and 39 which have been substituted for original Claims 31 and 32, each of these claims clearly and definitely bringing out the cooperation between the applicant's pressure responsive device and the light beam translation mechanism associated therewith, is respectfully requested. As will be readily appreciated by the Examiner, the diaphragm which is exposed to the well must be so enclosed that the effect of the static pressure in the well will be equalized on opposite sides of the diaphragm and in order to accomplish this result it is necessary that the diaphragm be enclosed within a pressure-tight housing. By reason of the necessity of enclosing the diaphragm, some means must be provided for exteriorly receiving and translating the motions of the

Defendant's Exhibit T—(Continued)

diaphragm which can be accomplished by providing a window in the housing and projecting a light beam through the window without interferring in any manner with the sensitivity of response of the diaphragm to the pressure waves sought to be translated. Thus the light beam translation device becomes an important element cooperating with a diaphragm pressure responsive device for the applicant's apparatus.

There is no enclosing of the diaphragm in the Batcheller patent. There is no equalizing of pressure on both sides of the diaphragm in the Batcheller patent. The Taylor patent does not contemplate any such problem as that presented to the applicant, nor does it disclose how the light beam translation means could be adapted to the applicant's purpose and to solve the applicant's problem, namely, that of transmitting and translating motions of an enclosed diaphragm to an exterior translation or receiving device. It would be impossible to produce the applicant's result by combining the Batcheller disclosure with the Taylor disclosure unless the important elements, namely, (a) the housing with its pressure equalizing means, and (b) the window through which the motions of the enclosed diaphragm can be observed and translated exteriorly of the housing, were added to the combined disclosures. It is the new combination of the elements shown in the Batcheller patent and the elements shown in the Taylor patent plus the

Defendant's Exhibit T—(Continued)

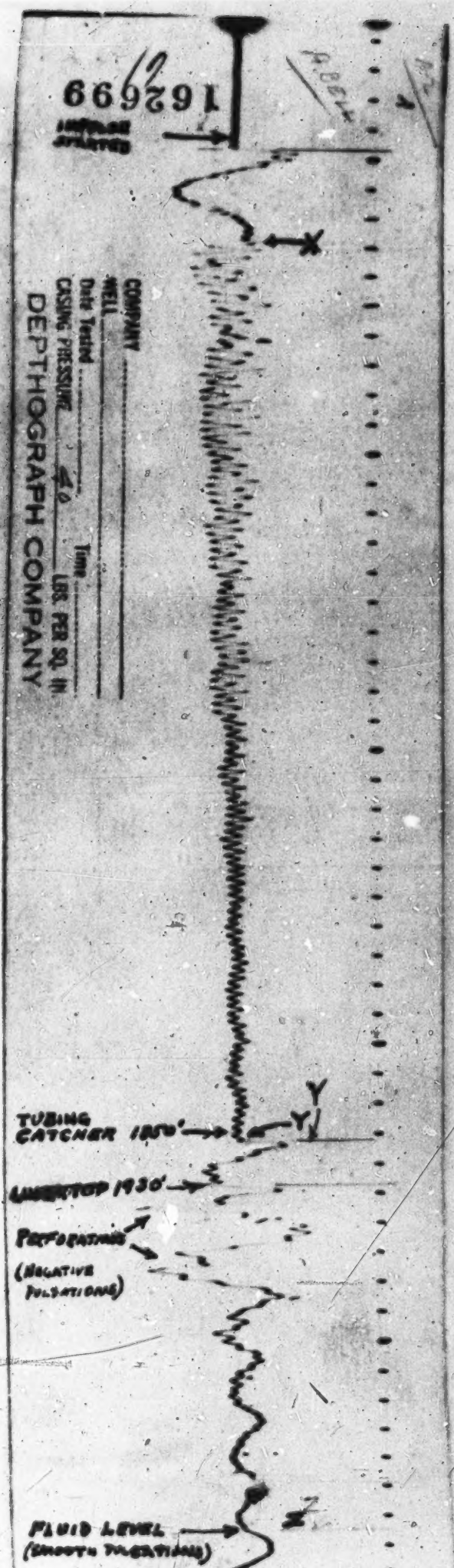
new elements found in neither of these prior patents which constitutes the applicant's patentable contribution, as expressed in Claims 38 and 39.

The remaining claims in this application stand allowed and it is believed that in view of the foregoing arguments all of the claims of this application will be found allowable and an early favorable action is respectfully requested.

Respectfully submitted,

HAROLD W. MATTINGLY,
Attorney for Applicant.

HWM:MM
Encl. Graph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Defendant's Exhibit T—(Continued)

Div. 5 Room 3077 260 CLJ/HMR

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Paper No. 5
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Department of Commerce
United States Patent Office
Washington
June 15, 1938

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,
Commissioner of Patents.

Mailed Jun 15 1938

Harold W. Mattingly,
924 Pacific Finance Building,
621 S. Hope Street,
Los Angeles, California.

Applicant: Cranford P. Walker
Ser. No. 162,699
Filed Sept. 7, 1937
For Method and Means for Measuring The
Location of Obstructions in Wells.

Defendant's Exhibit T—(Continued)

Responsive to amendment of April 21, 1938.

Additional reference cited:

Lehr et al, 2,047,974 July 21, 1936 181/0.52

Claims 17, 18, 27, 31, 32 and 37 are canceled

Claims 1 to 16 (claims 14 to 16 being formerly held allowable) and claims 19 to 23 are, upon careful reconsideration, again rejected as pointed out in the last office letter.

In claim 1, for example, there are two method steps set forth of (a) "creating a pressure impulse in the well" and (b) "measuring the lapse of time." Now these two method steps are clearly shown to be old by Batcheller of record, and Lehr et al. above cited. The statement that the "impulse is variably selected" does not add anything patentable to the claim and is at most a mere functional statement. That the echo arrives at the recording point with sufficient energy to make a record is not new with applicant in view of Batcheller and Lehr. It does not involve invention to make several trials to determine which is the best amplitude of sound waves generated to give satisfactory results.

Applicant argues (amendment of April 21, 1938) that the "pressure impulse of arbitrarily selected magnitude as disclosed in Batcheller may produce a result" but only "by chance and accident." It is believed, however, that Batcheller could, by trial, determine just what "magnitude" would give suitable and useful results.

Defendant's Exhibit T—(Continued)

Claims 5 and 6 are further rejected as indefinite and improper in that the mere selecting of the best impulse is not such as to entitle applicant to a patent therefor. The "creating in the well of a series of pressure impulses" is understood merely to mean that preliminary impulses are created until a suitable one is found, then the method is carried out using the suitable impulse. It is not seen to be a part of the process to carry out experiments or tests to determine the best conditions for carrying out the method.

Claims 22 and 23 are again rejected as pointed out in the last office letter.

Claims 24 to 26, 28 to 30, 33 to 36, 38 and 39 are deemed to be allowable.

C. W. ROBINSON,
Examiner.

Defendant's Exhibit T—(Continued)

Mail Division Jun 17, 1938 U. S. Patent Office.
Received Jun 18 1938 Division 5. Paper No. 6.
Amendment B.

In the United States Patent Office
Division 5—Room 3077

Cranford P. Walker
Method and Means for Measuring
the Location of Obstructions
in Wells

Filed September 7, 1937
Serial No. 162,699.

Los Angeles, California
June 13, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Supplementing the amendment dated April 19, 1938, please amend the above identified application as follows:

Add the following claims.

B1

10 ~~—40~~. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being divided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose

Defendant's Exhibit T—(Continued)

one face of the diaphragm to the medium, a by-pass extending between the compartments to equalize the static pressure of the medium on opposite faces of the diaphragm, light-reflecting means associated with the diaphragm, means for directing a light beam upon said reflecting means to reflect the beam through said window, means disposed exteriorly of said housing for receiving and translating the reflected beam, and means extending into said housing to adjust the position of said reflecting means to adjustably direct the reflected beam upon said receiving means.

11 ~~—41~~. In a device for measuring pressure waves in a fluid medium under static pressure, a diaphragm, a pressure-tight housing surrounding said diaphragm and having a window therein capable of passing light between the interior and exterior of the housing, said housing being devided by the diaphragm into two compartments, one on each side of the diaphragm, a medium entrance communicating with one compartment to directly expose one face of the diaphragm to the medium, a by-pass extending between the compartments to equalize the static pressure of the medium on opposite faces of the diaphragm, a light reflector associated with said diaphragm, means pivoting said reflector within the housing

^ ~~casing~~, means connecting said diaphragm and said reflector to move said reflector about its pivot in accordance with deflections of said diaphragm, means for projecting a beam of light upon said re-

Defendant's Exhibit T—(Continued)

flecting means to reflect said beam through said window, means disposed exteriorly of said housing for receiving and translating the reflected beam, and handle means projecting through said housing ~~casing~~ and accessible exteriorly thereof for adjusting said reflector pivot means to adjustably direct the reflected beam upon the receiving means.

REMARKS

New claims 40 and 41, inserted herewith, are drawn along the lines of claims 38 and 39, directed to the diaphragm housing and light beam reflecting mechanism shown particularly in Fig. 5 of the drawings, new claims 40 and 41 being directed to an important feature of this construction by which, even though the casing is of gas construction, the reflector may be readily adjusted from the exterior of the casing to direct the reflected beam of light to any suitable or desired position upon the screen or record tape. This is an important feature of the applicant's construction, particularly in view of the fact that the conditions encountered in different wells may vary through such wide limits that the reflector, properly positioned for measuring one well, will be so improperly positioned when used on another well as to throw the reflected light beam substantially off of the record chart or the screen. Hence, by providing the simple pivotal mounting for the fulcrum 30 for the reflector and employing the adjusting screw 33, accessible from the exterior

Defendant's Exhibit T—(Continued)

of the housing, the fulcrum point may be so readily changed as to permit direction of the beam to a desired position (usually centrally) of the record chart. The necessity for such adjustment is occasioned by the fact that the casing for the instrument must be gas tight and ordinary adjustment devices would not operate under these conditions.

In reconsidering the rejection of claims 1-6 the Examiner's attention is called to the fact, more clearly brought out in the remarks accompanying the amendment of April 19, 1938, that the normal gas pressure existing in different wells varies through such wide limits that it is necessary to select a pressure impulse value which must vary also within wide limits. In actual practice the applicant has discovered that a pressure impulse of only ten pounds may be perfectly satisfactory on one well while on other wells it has been necessary to use a pressure impulse in the nature of 600 pounds. For this reason it is evident that the Batchellor device, disclosing only the employment of a cartridge as the means for producing a sound wave or a pressure impulse, could not be successfully used for the measurements obtained by the applicant and that the claims of this application directed to the method and apparatus for producing pressure impulses of varying magnitude defines an important advance in this art over any of the teachings in the Batchellor patent.

Upon reconsideration it is believed that all of the claims heretofore presented and the two addi-

Defendant's Exhibit T—(Continued)

tional claims 40 and 41 presented herewith will be found allowable.

An early, favorable action is requested.

Respectfully submitted,

HAROLD W. MATTINGLY,
Attorney for Applicant.

HWM mm

Div. 5—Room 3077 260

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and not any official by name

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Defendant's Exhibit T—(Continued)

Paper No. 7

All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Department of Commerce
United States Patent Office
Washington

Sept. 12, 1938

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,
Commissioner of Patents.

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope Street
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 162,699
Filed Sept. 7, 1937
For Method and Means for Measuring the Location of Obstructions in Wells.

Mailed Sep 12 1938

Responsive to amendment filed June 17, 1938.
It is noted that the amendment received June

Defendant's Exhibit T—(Continued)

17, 1938, is not responsive to the office action of June 15, 1938.

Complete response to the office action of June 15, 1938, must be made within the statutory six months period in order to save this case from abandonment.

C. W. ROBINSON,
Examiner.

Received Dec 13 1938 Division 5, Paper No. 8 Amendment C.

Mail Division Dec 12 1938 U. S. Patent Office.

In the United States Patent Office
Division 5—Room 3077

CRANFORD P. WALKER
METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed September 7, 1937
Serial No. 162,699

Los Angeles, California
December 8th, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of June 15, 1938, please amend the above entitled application as follows:

Defendant's Exhibit T—(Continued)

Cancel Claims 1, 2 and 3 and substitute the following:

(C)

—42. The method of determining the unknown location of an obstruction in a well which has a restricted passage therethrough, which consists in creating in the well a series of pressure impulses of varying magnitude, observing the echoes of each impulse to select one pressure impulse amplitude which produces an echo from the unknown obstruction readily distinguishable from other echoes of that impulse, and measuring the lapse of time between the creation of the selected impulse and the arrival at a predetermined point of the echo from the unknown obstruction.—

Cancel Claims 4, 5 and 6 and substitute the following:

(E)

—43. The method of accurately determining the location of obstructions in wells, which consists in creating in the well a series of pressure impulses each of different amplitude, observing the echoes thereof from different obstructions in the well to select that amplitude of impulse which produces echoes from the different obstructions distinguishable one from the other, then utilizing said selected amplitude for measuring the lapsed time between the creation of the impulse and the arrival at a predetermined point of each of the distinguishable echoes to measure the distance from

Defendant's Exhibit T—(Continued)

said predetermined point to each of the different obstructions.—

Cancel Claims 7, 8 and 9 and substitute the following:

—44. The method of determining the unknown location of an obstruction in a well (~~E²~~) having another obstruction therein at a known location, annular space an acoustical which consists in creating in the ~~well a pressure~~ impulse of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from different obstructions distinguishable from each other, observing the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the known obstruction to thereby determine the velocity of the pressure wave in that particular well, and measuring the lapse of time between the creation of the impulse and the arrival at said predetermined point of the echo from the unknown obstruction.—

Cancel Claims 10 and 11 and substitute the following:

—45. The method of determining the unknown location of an obstruction in a well containing a gaseous medium and having an obstruction therein at a known location below the ground surface, which consists in creating the pressure impulse in the well at the ground surface, observing the lapse of time between the creating of the impulse and the arrival at the ground surface of an echo from the

Defendant's Exhibit T—(Continued)

~~known obstruction to thereby determine the ve~~locity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at the ground surface of the echo from the unknown obstruction.—

Cancel Claim 12 and substitute the following:

—46. The method of determining the unknown location of an obstruction in a well having a string of tubing therein, which consists in creating ∧ ~~a pres~~ an acoustical annular space between the tubing and the casing in the ~~sure~~ impulse in the ∧ well of such magnitude as compared with the depth of the well and the resistance to pressure wave transmission therethrough as will produce echoes from portions of the tubing string distinguishable from the echo from the unknown obstruction, observing the lapse of time between the creation of the impulse and the echoes from successive portions of the tubing string to thereby determine the velocity of the pressure wave through the particular well under measurement, and measuring the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.—

Cancel Claim 13 and substitute the following:

—47. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately

Defendant's Exhibit T—(Continued)

the same length and connected to each other by couplings, which consists in creating a pressure impulse in the well, noting the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echoes from the successive couplings of the tubing lengths to accurately determine the velocity of the pressure wave through the different portions of the well, and measuring the lapse of time between the creation of the pressure impulse and the arrival at said predetermined point of the echo from the unknown obstruction.—

Insert the following claim between Claims 14 and 15:

—48. The method of determining the unknown location of an obstruction in a well containing a gaseous medium, which consists in determining the velocity of pressure waves through the gaseous medium in the well under measurement, creating a pressure impulse in the well, and noting the lapse of time between the creation of the impulse and the arrival at a predetermined point of the echo from the unknown obstruction.—

Claim 16, Lines 5 and 6, change "lengthening or shortening" to read—adjusting the length of—

Insert the following claims between Claims 15 and 16:

—49. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approxi-

Defendant's Exhibit T—(Continued)

~~mately the same length, which consists in creating~~ a pressure impulse in the well, providing a pressure responsive device in communication with the well to receive and translate the echoes from the various obstructions therein and so tuned to the frequency of the echoes from the couplings of the tubing sections as to clearly distinguish the echoes from the couplings from each other to thereby determine the velocity of the pressure wave within the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.

—50. The method of accurately determining the unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately the same length, which consists in creating a pressure impulse in the well, coupling the well to a pressure responsive device to translate echoes from the several obstructions in the well, so tuning the pressure responsive device to the frequency of the echoes received from the couplings of the tubing sections as to accent these echoes, noting the frequency of the echoes from the couplings of the tubing sections to determine the velocity of the pressure wave in the particular well under measurement, and noting the lapse of time between the creation of the pressure impulse and the arrival at a predetermined point of the echo from the unknown obstruction.

Defendant's Exhibit T—(Continued)

—51. An apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means for creating a pressure impulse in said well, echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction, and means for so tuning said pressure responsive device to the frequency of the echoes from the couplings of the tubing sections as to clearly distinguish the echoes from the couplings from each other to thereby determine the velocity of the pressure wave within the particular well under measurement.

1 —~~52~~. In an ∧ ~~An~~ apparatus for determining the location of an obstruction in a well having ∧ therein a string of assembled tubing sections ∧ interconnected with each other by coupling collars ~~therein~~, means (∧E⁶) for creating ∧ a ~~the~~ pressure impulse in said well, echo receiving means including a pressure responsive device exposed to said well for receiving pressure impulses from the well and for measuring the lapse of time between the creation of the impulse and the arrival at said receiving means of the echo from said obstruction, and means associated with said pressure responsive device for tun-

Defendant's Exhibit T—(Continued)

~~ing said receiving means to the frequency of echoes~~ from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other.—

Cancel Claims 20, 21, 22 and 23 and substitute the following claim:

—53. In an apparatus for determining the unknown location of an obstruction in a well, means communicating with said well at the well head ^ for creating pressure impulses in the well, means ^ for controlling the magnitude of the pressure impulses created in said well, a pressure responsive device coupled to said well and movable in response to pressure variations in said well, means for visually observing the movements of said pressure responsive device to thereby select the magnitude of pressure impulse for that well which will produce an echo from the unknown obstruction distinguishable from other pressure variations in the well, and means (^E[4]) ~~for measuring the lapse of time~~ between the creation of said selected impulse and the arrival at a predetermined point of the echo thereof from the ~~unknown obstruction.~~

Claim 24, Line 7, change "lengthening or shortening" to read—adjusting the length of—.

Claim 25, Line 7, change "lengthening or shortening" to read—adjusting the length of—.

Claim 16, Line 3, after "having" insert—located

Defendant's Exhibit T—(Continued)

~~therein—; same line, after "tubing" cancel "located~~ therein" and substitute—sections interconnected by coupling collars—; Line 9, change "couplings" to read—collars—.

REMARKS

This amendment is made not only to the Office action of June 15, 1938 but also in response to an oral interview had with the Assistant Examiner and the Primary Examiner about October 17, 1938.

As pointed out in that interview, this applicant has not merely presented for consideration a theoretical structure and a theoretical method of operation but has instead presented an application to cover methods and apparatus which he has developed and made available to the oil industry to provide this industry with accurate and reliable measurements, not only of the location of the fluid level or other obstructions in old existing wells but also accurate and reliable information as to the proper location for pumps, the fluid density at various points below the liquid surface and the only inexpensive method of determining the potential capacity of a well pumped by a mechanical pump.

The oil industry has welcomed his development, his organization and the service they perform, with open arms and have come to rely upon them for this information which is otherwise either totally unobtainable or obtainable only by such laborious and expensive means as to render it almost prohibitive. The applicant's methods and service have been used and are now being used by the major oil com-

Defendant's Exhibit T—(Continued)

panies and statements or affidavits can be obtained from them demonstrating that the applicant has supplied a long felt want in this industry.

Therefore, in considering the claims of this application, the Examiner must keep in mind that the applicant has advanced this art by performing for the first time new, accurate and reliable methods of obtaining important information for the industry and he is not to be denied patent protection upon his contributions unless the Examiner can show that the same concept of invention is disclosed in the prior art.

Taking up for consideration first the subject matter of Claims 14, 15 and 16, which the Examiner originally allowed but then in the Office action of June 15, 1938 blanketed with Claims 1 through 6, etc. in an unexplained rejection, the Examiner at the oral interview stated that such rejection of these claims was an inadvertent error though he pointed out some minor corrections which were needed in Claim 16. These corrections have been made.

The subject matter of Claims 14, 15 and 16, as well as new Claims 45, 46, 47, 48, 49, 50, 51 and 52, is directed to that step of the applicant's method which converts the inaccurate and unreliable results obtainable from the Batcheller and from the Lehr et al. practices to accurate and reliable measurements. The applicant in developing his system discovered that the results obtained were inaccurate because each well has a different gaseous medium therein and only by observing and measuring the actual velocity of

Defendant's Exhibit T—(Continued)

the pressure wave in the well under test is it possible to achieve accurate and reliable results. He provides three different ways of determining this velocity:

(1) separating the results of the echo from an obstruction at a known location within the well in some manner so as to render it distinguishable from the echo from the unknown obstruction or liquid surface. Thus by noting the time lapse required for the echo from the known obstruction he has an accurate measurement of the velocity of the pressure, not in oil wells in general but in that particular well under test. He has observed that the velocity in different wells may vary from 750 feet per second to 1400 feet per second so that unless the velocity in the well under test is known the results cannot be accurate;

(2) He provided a means for tuning the receiving instrument in such manner that the echoes from the tubing coupling collars were readily distinguishable one from the other so that by counting the tubing collar echoes in a given period of time he could accurately determine the pressure wave velocity; and

(3) He provided an instrument at the ground surface through which the gaseous medium in the well could pass and there made his determination of pressure wave velocity in that gaseous medium in the particular well under measurement.

Claim 48 is directed to the generic idea of combining the two steps (1) determining the velocity in the well under measurement and then (2) using this velocity in combination with the echo prin-

Defendant's Exhibit T—(Continued)

ciple to determine accurately the location of the unknown obstruction.

Claims 45 and 14 are directed specifically to the first of the three methods of determining the velocity noted above.

Claims 15, 46, 47, 49, 50, 51 and 52 are all directed specifically to the second method noted above for determining the pressure wave velocity, namely, the tuning of the receiving instrument so as to accent the tubing collar echoes and thus permit them to be distinguished from each other and to be counted.

At the oral interview the Examiner questioned Claim 14 as possibly aggregational but it is believed that not only Claim 14 but all of the remaining claims in this group are clearly and definitely a statement of steps which are dependent one upon the other to achieve the accurate result obtained by the applicant. It was the failure of the prior art to take into consideration this difference in velocity which kept the prior art methods from accomplishing any substantial advance in this art. Unless the Examiner can find a reference which teaches this concept of the invention, all of these claims must be allowed.

To assist the Examiner in the consideration of this group of Claims, new Claim 48 defines this method broadly while Claim 14 is specific in that it recites the observation of the echo from an obstruction of known location for the determination of the velocity.

Defendant's Exhibit T—(Continued)

Claim 49 is directed broadly to that method which includes the tuning of the receiving device to accent the echoes from the tubing couplings which may be accomplished by initially selecting a receiving device having the tuned characteristics.

Claim 50 is directed to the same subject matter as Claim 49 but brings out the additional step of variably tuning the receiving device after it is coupled to the well.

Claim 51 is an apparatus claim similar to allowed Claims 24, 25 and 26, and defines the receiving device with a "means" for tuning the receiving device. Claims 24 and 25 are directed more specifically to this tuning by the adjustment of the length of the coupling between the pressure responsive device and the well.

Each of these claims has been carefully drawn to distinguish one from the other and it is believed that the applicant is entitled to the protection afforded by each of these claims.

Now considering that group of claims directed to the employment of a succession of impulses of different magnitude, the Examiner rejected Claims 1 through 6, etc. on the patents to Batcheller and Lehr et al., upon the ground that it would not amount to invention to make several trials to determine which is the best amplitude to give satisfactory results. All of the claims directed to this subject have been cancelled and new Claims 42, 43, 44, 45, 46 and 53 have been substituted therefor. In each of these claims it has been carefully brought

Defendant's Exhibit T—(Continued)

out that it is not a mere selection of a pressure impulse of one magnitude or another magnitude by a cut and try method but instead what is sought to be covered is the selection of an impulse and the observation of the effect of this impuse to determine when an impulse has been found which will give clearly distinguishable echoes from different obstructions in the well.

Upon reviewing Claims 1 through 6, etc. directed to this subject matter, it is believed that these claims did not properly bring out the applicant's real contribution in this line but that new Claims 42 through 46 and 53 do properly set forth this contribution. Again the Examiner's attention is called to the fact that the applicant discovered the reasons for the failures in prior attempts to use the pressure echo method for obtaining these results, namely, that each well had different characteristics from those of other wells and that improper magnitude of impulse would give either no results or results which could scarcely be read. By introducing that new step, namely, of variably selecting the amplitude, observing the effects of the amplitude, he could change failure into success. It is believed that the new claims bring out this contribution and that each of them is clearly allowable.

Claim 42 is directed broadly to this new step.

Claim 43 is directed to the subsequent utilization of an impulse the magnitude of which has been previously determined as set forth.

Claim 44 is directed broadly to the utilization of

Defendant's Exhibit T—(Continued)

an impulse selected in accordance with the known characteristics of the well with regard to depth and resistance to the pressure wave transmission to produce distinguishable echoes from different obstructions and thus permit the applicant to observe these distinguishable echoes as a means for determining pressure wave velocity.

Claim 45 is directed to the same subject matter as Claim 44 but defines the point of origin of the impulse and the point of reception of the echo as being at the ground surface.

Claim 46 is similar to Claims 44 and 45 but applies the method to a well containing a tubing string and selecting the impulse of such magnitude as will give distinguishable echoes from the different tubing sections.

Claim 47 is similar to Claim 46 but defines the feature that where the tubing sections are of the same known length the impulse produces distinguishable echoes from all of the tubing sections to permit the observation and determination of the velocity through different portions of the well.

All of these claims define steps and features which are not found in the prior art and it is their absence from the prior art knowledge which defines the difference between success and failure of the system.

Claim 53 has been substituted for Claims 20, 21, 22 and 23 and is directed to the apparatus by which the applicant can produce impulses of different magnitude, which includes means for producing

Defendant's Exhibit T—(Continued)

variable impulses and means for visually observing the movement of a pressure responsive device so as to determine when the distinguishable echoes are produced. This is a feature not contemplated in any of the prior art devices and this claim is also clearly allowable.

It is noted that no action has been taken upon newly submitted Claims 40 and 41 but it is pointed out in the amendment filed June 17, 1938 how each of these claims is clearly patentable over the art of record.

It is believed that upon reconsideration of this application, particularly in view of the careful presentation of each of the claims remaining in this case, it will be found that each of them is directed to and does define those differences over the prior art which makes the applicant's device a successful achievement in this industry and that each of the claims will be found to be allowable.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney for Applicant.

HWM:MM

Defendant's Exhibit T—(Continued)
In the United States Patent Office
Division 5—Room 3077

Mail Division Dec 15 1938 U.S. Patent Office.

Received Dec 16 1938 Division 5, Paper No. 9, Amendment D.

Via Air Mail
Confirmation
Regular Mail

CRANFORD P. WALKER
METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed September 7, 1937
Serial No. 162,699

Los Angeles, California
December 13, 1938

Hon. Commissioner of Patents
Washington, D. C.

Sir:

Supplementing the amendment forwarded to the Patent Office in the above identified application on December 8, 1938, please amend said application as follows:

Cancel Claim 19.

REMARKS

It is noted that in the amendment filed in the above application, forwarded to the Patent Office on December 8, 1938, instruction to cancel Claim 19 was inadvertently omitted, the subject matter of

Defendant's Exhibit T—(Continued)

this claim being fully covered by new Claims 42 and 43.

Respectfully submitted,
HAROLD W. MATTINGLY
Attorney for Applicant.

HWM:MM

In the United States Patent Office

Application Div. U.S. Patent Office. Feb 9 '39.

Received Feb 9 - 1939, Division 5, Paper No. 10,

Amendment E.
In the application of
Cranford P. Walker

Method and Means for Measuring
the Location of Obstructions
in Wells

Filed Sept. 7, 1937
Serial No. 162,699

Div. 5
Room 3077
Washington, D. C.,
Feb. 9, 1939

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Supplementing the amendment of December 8, 1938, please amend the above entitled application as follows:

Cancel claims 42 and 43, and substitute the following:

Defendant's Exhibit T—(Continued)

E1

~~54. The method of determining the unknown lo~~cation of an obstruction in a well having a casing with tubing therein restricting the volume of the annular space within the casing and having an approximately known depth and a known pressure of gas within said space, from which the approximate magnitude of acoustical impulse required to traverse the restricted space and produce echoes from the several obstructions in the well may be determined, which consists in introducing into said space between the casing and tubing a series of acoustical impulses, each of different magniture approximating the determined magnitude to produce from each impulse echoes from the different obstructions in the well, observing the echoes that are produced by each impulse to select the one that produces distinguishable echoes from each of the obstructions in the well, and recording the echoes of an impulse of the selected magnitude in the relative times and order in which they are received at the ground surface.

Claim 44, line 2, after "well" insert

E2

—having a casing with tubing therein restricting the volume of the annular space within the casing and

—; line 4, cancel "well a pressure" and substitute —annular space on acoustical—.

Cancel claim 45.

Defendant's Exhibit T—(Continued)

Claim 46, line 3 cancel "a pressure" and substitute—an acoustical—; line 4, before "well" insert —annular space between the tubing and the casing in the—.

Cancel claim 47 and substitute the following:

E3

~~55 56. The method of accurately determining the~~ unknown location of an obstruction in a well having a string of tubing therein constructed of a plurality of lengths of tubing, each of approximately the same length and connected to each other by couplings, which consists in creating a pressure impulse in the annular space between the tubing and casing of the well, recording the echoes from the tubing collars and from said obstruction, and counting the tubing collar echoes between the creation of the pressure impulse and the echo from the unknown obstruction, to determine the location of the un~~known obstruction.~~

Cancel claim 51.

Claim 52, line 2 after "having" insert—therein—; line 3, cancel "therein" and substitute—interconnected with each other by coupling collars—; line 3 after "means" insert

E6

—communicating with said well—.

Claim 53, line 3 after "head" insert —communicating with said well—; line 4, after "means" insert —associated with said impulse creating means —; cancel from "for" in line 12 to end of the claim and substiute the following

Defendant's Exhibit T—(Continued)

E4

~~—associated with the said pressure responsive device~~ for recording the echoes in the relative times and order in which they are received by the ~~pressure responsive device—~~.

Claim 16, line 7, change "coupling" to read —pressure responsive device—.

Claim 24, line 3 after "means" insert —communicating with said well—; line 8, change "pipe" to read —pressure responsive device—.

Claim 25, line 3 after "means" insert —communicating with said well—; line 8 change "pipe" to read —pressure responsive device—; line 10, after "means" insert —associated with said pressure responsive device—.

Claim 26, line 3 after "means" insert —communicating with said well—; line 6, change "pipe coupling" to read —means intercoupling—; line 6, change "to" to read —with—; line 7, change "pipe" to read —pressure responsive device—; line 8, change "impulses" to read —impulse—; line 10, after "means" insert —associated with said pressure responsive device—.

Claim 28, line 2 after "means" insert —communicating with said well—.

Claim 29, line 2, after "means" insert —communicating with said well—.

Claim 30, line 2, after "means" insert —communicating with said well—.

Claims 34 and 35, lines 3 after "means" insert

Defendant's Exhibit T—(Continued)

—communicating with said tube—; lines 4, after "means" insert —associated with said tube—; line 5, after "means" (first occurrence) insert —associated with said pressure wave creating means—; lines 4 5, after "means" (second occurrence) insert —communicating with said tube—.

Claim 36, line 3 after "means" insert —communicating with said tube—; line 4, after "means" insert —associated with said tube—; line 5, after "means" insert —associated with said pressure wave creating means—.

Add the following claims:

E5

~~56. In an apparatus for determining the location~~ of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure impulse receiving means responsive to echoes from the couplings of the tubing string and to the echoes from other obstructions, means coupling said pressure receiving means to the well to expose said device to pressure variations existing in said well, and means associated with said device for recording the echoes to permit counting ~~of the same.~~

12 ~~57~~. In an apparatus for determining the location of an obstruction in a well having a string of assembled tubing sections therein, means communicating with said well for creating a pressure impulse in said well, a pressure responsive device for receiving pressure impulses from the well, means cou-

Defendant's Exhibit T—(Continued)

pling said pressure responsive device to the well to expose said device to pressure variations existing in said well and having a length approximately a multiple of the length of a tubing section to tune said device to the frequency of the echoes of the impulse received from the couplings of the tubing string, and means associated with said device for recording the echoes from the tubing couplings and from said obstruction to permit counting the coupling echoes between the creation of the impulse and the echo from the unknown obstruction to determine its location.

REMARKS.

This is to acknowledge the interview courteously granted by the Examiner on February 7th, at which time the applicant and the attorney of record, presented to the Examiner some of the history of the development of the invention claimed in this application and the importance thereof to the oil industry.

At that interview, the claims of this application were carefully reviewed and discussed with the Examiner and in view of the suggestions made by the Examiner all of the allowed claims have been amended to more clearly bring out the association of the interrelation of the various elements recited, and to avoid the criticism of functionality. In this respect the Examiner's suggestions are sincerely appreciated.

With regard to that part of the subject matter of the applicant's invention relating to the desirability

Defendant's Exhibit T—(Continued)

and the necessity for employing impulses of various magnitude in order to produce a group of recordable echoes in which the echoes of each of the different obstructions such as tubing collars or couplings, tubing catches, liner tops and liquid surface can be readily distinguished from each other. It was pointed out to the Examiner that when measurements are to be made in a well of relatively shallow depth and in which the annular space between the walls of the casing and the walls of the tubing is relatively great an impulse of great magnitude produces such reverberations as to confuse the echoes received from these different obstructions and in such case an impulse of small magnitude must be used. On the other hand where the well is deep or where the annular space is restricted an impulse of greater magnitude is required and may be successfully employed without producing the confusing reverberations. Again, in some wells in which the gas pressure is relatively high an impulse of small magnitude will produce successful results while an impulse of great magnitude produces only confusion.

It was failure of the prior art as exhibited in Batchellor and Lehr et al patents which prevented these devices from being successfully used, even though the oil industry was constantly seeking a ready method of making fuel level determinations and made many attempts to apply the teachings of the Batchellor and Lehr et al patents for this purpose.

Defendant's Exhibit T—(Continued)

Claims 42 and 43 which presented this subject matter have been canceled and a new claim 54 has been substituted which it is believed expresses this phase of the applicant's invention properly. Again, the suggestions of the Examiner relative to the character of this claim are appreciated.

New claim 55 is presented herewith directed to the same subject matter as allowed claim 26, but particularly directed to the feature of employing the distinct echoes from the tube collars or couplings as a means of determining the location of the liquid level or other obstruction by counting the number of tube collar echoes received. This subject matter is disclosed on pages 19 and 20 of the original specification, and is believed to be clearly distinguished from any suggestion or teaching contained in the prior art.

New claims 56 and 57 are apparatus claims drawn to this same subject matter definitely setting forth the structure by which this result may be accomplished. Claim 56 defines the apparatus required to produce a distinguishable set of echoes from the tubing collars and for counting these echoes as the means for determining the location of the liquid surface, while new claim 57 brings in the additional structure required to "tune" the receiving device to accent these echoes so that they are more clearly distinguished from each other and can be more readily segregated and counted.

As was discussed with the Examiner at the inter-

Defendant's Exhibit T—(Continued)

view this applicant has produced for the first time a method and an apparatus which enables the oil industry to locate the position of the liquid surface, the position of tubing catchers, liner tops, pumps, perforated liners or other obstructions which may be in the well in an extremely inexpensive manner and which has been welcomed and adopted by the oil industry as the solution for the heretofore vexing and unsolved problem to obtain accurate information of this character. The applicant is prepared to submit affidavits, not only showing the immediate adoption and use of the applicant's method and apparatus by the major oil companies in the United States, but also their enthusiastic welcoming of this invention as the solution of one of their vexing problems which has caused great loss of time and great loss of money to the industry.

It is believed that upon reconsideration of this application in the light of the foregoing amendments, and the arguments presented in this case, each of the claims now presented will be found allowable, and an early and favorable action is requested.

Respectfully submitted,

HAROLD W. MATTINGLY

Attorney.

Received Feb 15 1939 Division 5. Paper No. 11

Pet. to Make Special.

In the United States Patent Office

Cranford P. Walker

Defendant's Exhibit T—(Continued)

Method and Means for Measuring the Location of Obstructions in Wells

Filed September 7, 1937

Serial No. 162,699

PETITION TO MAKE APPLICATION SPECIAL

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Now comes your petitioner, by his attorney of record, and requests that this application be made special for examination, and that the Examiner in charge thereof be instructed to take this application up for action out of its regular turn.

Your petitioner avers that he is engaged in the business of making surveys of oil wells to determine locations of the fluid levels and the locations of other obstructions in the wells by the use of sonic echo methods and apparatus, as set forth and claimed in this application.

That applicant's methods and apparatus as described and claimed in this application have met with instant commercial success and has been adopted as standard practice by the major oil companies of the United States.

That until applicant introduced his apparatus and methods to the oil industry, no similar method and apparatus was known to the industry.

That, subsequent to applicant's introduction of

Defendant's Exhibit T—(Continued)

his methods and apparatus, representatives of a competitor, International Geophysics Inc., then engaged in a non-competitive activity, inspected applicant's apparatus and methods and took photographs of applicant's apparatus and, thereafter, entered the field with similar apparatus and similar methods of obtaining fluid level determinations and measurement of obstructions in wells.

That the competitor by reason of the employment of the apparatus and methods is seriously damaging and threatens to destroy applicant's business and to deprive the oil industry and the public from receiving the benefits of applicant's invention and to injure the oil industry to an extent unless these activities can be controlled by patents and licenses thereunder.

That, in the opinion of your petitioner and his attorney of record, the apparatus and the methods practiced by the competitor constitutes an infringement of each and every of the claims now presented in this application.

That, until the patent is granted to applicant he is helpless to prevent this destructive competition.

That your petitioner further avers he has actively and diligently prosecuted this application by prompt amendments and by attempts to secure personal interviews with the Examiner in charge thereof for the purpose of expediting the prosecution of this case.

Your petitioner further avers that both he and his attorney of record have diligently searched the

Defendant's Exhibit T—(Continued)

prior art and, in the opinion of his attorney of record, each and every of the claims now presented in this application is patentable.

That in a companion application filed by your petitioner, Cranford P. Walker, on October 26, 1937, Serial No. 171,170, entitled Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, a similar petition to make that application special was filed and attached thereto were affidavits and exhibits establishing the infringing activities of the same competitor, International Geophysics Inc., and evidence tending to establish applicant's priority in this field. It is requested that the said affidavits and exhibits be considered as a part of this petition and to make this application special.

Attached hereto and made a part hereof are affidavits by Cranford P. Walker and Harold W. Mattingly, his attorney of record, establishing the facts set forth in this petition.

Respectfully submitted,

CRANFORD P. WALKER

By HAROLD W. MATTINGLY

His Attorney

Washington, D. C.,
February 11, 1939.

Defendant's Exhibit T—(Continued)
Mail Division Feb 11 1939 U.S. Patent Office.
In the United States Patent Office

CRANFORD P. WALKER

METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed September 7, 1937.

Serial No. 162,699

AFFIDAVIT OF CRANFORD P. WALKER

Cranford P. Walker, being duly sworn, deposes and says that he is the applicant named in the above-entitled application for United States Letters Patent.

That on February 11, 1939, he filed a petition to make application special in the matter of his co-pending application, Serial No. 171,170, filed October 26, 1937, for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, and he adopts as a part of this affidavit each and every of the statements set forth in his affidavit accompanying that petition.

Affiant further states that he has personally inspected the apparatus employed by the competitors, International Geophysics Inc., and that the same incorporates mechanism for producing pressure waves in wells, mechanism for recording the same, and mechanism for tuning instruments to accent the echoes from tubing collars or similar regularly spaced obstructions in the wells.

Defendant's Exhibit T—(Continued)

That, in his opinion, the apparatus employed by the competitor constitutes an infringement of claims 24, 25 and 26 which have been allowed in this application.

CRANFORD P. WALKER

Sworn to and subscribed before me this 11th day of February, 1939.

FREDERICK A. ALLMITT
Notary Public

In the United States Patent Office

CRANFORD P. WALKER

METHOD AND MEANS FOR MEASURING THE LOCATION OF OBSTRUCTIONS IN WELLS

Filed September 7, 1937

Serial No. 162,699

AFFIDAVIT OF HAROLD W. MATTINGLY

Harold W. Mattingly, being duly sworn, deposes and says that he is the attorney of record in the above-entitled application.

That, on February 11, 1939, he filed a petition to make a copending application special for Cranford P. Walker, Serial No. 171,170, filed October 26, 1937, for Method of Determining Fluid Density, Fluid Pressure and the Production Capacity of Oil Wells, and adopts herein each of the statements made in affiant's affidavit attached to that petition.

Defendant's Exhibit T—(Continued)

That, in addition thereto, affiant has carefully compared the evidence submitted to him including the photographs accompanying the said petition and, in his opinion, the competitor, International Geophysics Inc., is clearly infringing claims 26, 27 and 28 of this application.

That the said claims have been allowed by the Patent Office and that affiant has caused to be made a thorough seach of the prior art and believes that each of the said claims is patentable to applicant.

HAROLD W. MATTINGLY

Sworn to and subscribed before me this 11th day of February, 1939.

FREDERICK A, ALLMITT
Notary Public.

Div. 5
Cranford P. Walker,
Ser. No. 162,699
Received Feb 15 1939 Division 5, Paper No.
The examiner will please send the file of this ap-
Mrs. Peterson, Room 3898
plication to ~~Mr. E. T. Newton, Room 3628,~~ indicating hereon when the application will be reached for action.

CONWAY P. COE
Commissioner.

Defendant's Exhibit T—(Continued)

This application will be acted upon within 3 weeks

Date Feb. 13 1939

[Longhand Note]: (for Division) only? J.W.M.

C. L. JUSTUS

(To be signed by person reporting.)

Department of Commerce
United States Patent Office
Washington
Address only the Commisioner of Patents
Washington, D. C.

U.S. Patent Office Commissioner's Office Feb 13 1939 Copy Mailed.

Received Feb 15 1939 Division 5, Paper No. 12 Com's Dec. (Pet. Granted)

Feb 13 1939

Ex parte Cranford P. Walker,
Serial No. 162,699,
Filed September 7, 1937,
Method and Means for Measuring
the Location of Obstructions in Wells.

PETITION TO MAKE SPECIAL.

The petition to make this case special has been considered.

If the examiner can make this case special without prejudice to any possible interfering applica-

Defendant's Exhibit T—(Continued)

tions, and he should make a rigid search for such, he is authorized to do so for the next action. Should the application be rejected again, the case will not be considered special for the subsequent action unless the applicant promptly makes a bona fide effort to place the case in condition for allowance even if it is necessary to have an interview with the examiner to accomplish this purpose.

If the examiner finds any interfering application for the same subject matter, he should consider such application simultaneously with this case and should state in the official letter of such application that he is taking it out of its turn because of a possible interference.

The petition is granted.

JUSTICE W. MACKLIN
First Assistant Commissioner.

Mr. Harold W. Mattingly,
924 Pacific Finance Bldg.,
621 S. Hope St.,
Los Angeles, Calif.

Defendant's Exhibit T—(Continued)

260

Department of Commerce
United States Patent Office
Washington
Div. 5 Room 3077
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
Paper No. 13
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Feb. 21, 1939

CLJ/H

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE
Commissioner of Patents,

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope Street
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 162,699,
Filed Sept 7, 1937
For Method and Means for
Measuring the Location of Obstructions in Wells

Mailed Feb 21 1939

Defendant's Exhibit T—(Continued)

Responsive to amendments filed December 12 and 15, 1938, and February 9, 1939.

The amendment of February 9, 1939, contains two claims 56, and the first one, to be substituted for claim 47, is renumbered by the examiner as claim 55 and will be so designated hereafter.

Claims 1 to 13, 17 to 23, 27, 31, 32, 37, 42, 43, 45, 47 and 51 are canceled.

Division is required between the claims as follows:

Group I, claims 14 to 16, 24 to 26, 28 to 30, 44, 46, 48 to 50 and 52 to 57 as drawn to a method and apparatus for determining the location of obstructions in wells; and

Group II, claims 33 to 36, 38 to 41 as drawn to a method and apparatus for determining the velocity of pressure waves in a given medium.

These two groups of claims are to separate and distinct inventions, each of which may be practiced without using the other.

Division is further required between the claims of Group I above as follows:

A. Claims 14 to 16, 46, 48 to 50, 54 and 55 drawn to the method; and

B. Claims 24 to 26, 28 to 30, 44, 52, 53, 56 and 57 drawn to apparatus for determining the unknown location of an obstruction in a well.

It is believed that the method and apparatus are two distinct and separate inventions, that the method can be carried out by other apparatus, and the apparatus can be used to carry out other methods.

Defendant's Exhibit T—(Continued)

Division is further required between the claims of Group II as follows:

A. Claim 33 drawn to a method; and

B. Claims 34 to 36 and 38 to 41 as drawn to an apparatus for measuring pressure wave velocity.

It is believed that the method and apparatus claims are to two separate and distinct inventions.

Claims 44, 46, 48 go 50 and 53 to 57 are rejected as being unpatentable over Lehr et al of record.

Considering claim 48, for example, the steps of "creating a pressure impulse in the well" and "noting the lapse of time" are the same as those recited in claim 9 of Lehr et al. The method step recited by applicant of "determining the velocity of pressure waves through the gaseous medium in the well" is a separate step and need not be performed with the other steps set forth. Furthermore, Lehr, on page 2 of his patent, discloses how the velocity of the impulse wave may be determined.

Claim 16 is rejected as indefinite in "adjusting the length of the coupling between the well and the pressure responsive device" implies that there is a definite structural element required to carry out the method step, yet that structure is not clearly set forth.

The above requirement for division constitutes a rejection of the application under ex parte Steinmetz v. Allen, 109 O. G. 549; 1904 C. D. 703; 192 U. S. 543.

C. W. ROBINSON,
Examiner.

Defendant's Exhibit T—(Continued)

Application Div. Mar 6 '39. U. S. Patent Office.
Received Mar 6-1939. Division 5 Paper No. 14.

Amendment F.

In the United States Patent Office
Division 5—Room 3077

Cranford P. Walker
Method and Means for
Measuring the Location
of Obstructions in Wells
Filed September 7, 1937
Serial No. 162,699

Los Angeles, California
March 3, 1939

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office action of February 21, 1939, please amend the above identified application as follows:

In the Petition, the preamble to the specification and the Oath, please change the title by striking out "Method And".

Page 1, Line 1, change "a method of" to read—devices for—; Line 3, cancel "methods and".

Page 3, Line 8, after "improve" insert—upon—; Line 12, cancel from "another" through the period in Line 26; Line 28, cancel "method" and substitute—device—.

Page 4, Lines 2, 10 and 24, change "a method and" and substitute—an—.

Defendant's Exhibit T—(Continued)

Page 5, cancel the paragraph beginning in Line 1 and ending in Line 7.

Page 12, Line 13, cancel "The pipe 18 is illustrated as being coupled" and substitute—A receiving device for receiving and registering the echoes of the pressure impulse from the various obstructions within the well is illustrated as including the pipe 18 and pressure responsive device coupled thereto—.

Page 14, line 7, after "and", delete the comma and insert—will cause the echo impulses to be registered for observation, both—; Line 8, delete the the comma and substitute—where—; Line 9, change "while" to read—and—.

Page 20, Line 2, change "of", first occurrence, to read—in—.

Cancel Claims 14, 15, 16, 33, 34, 35, 36, 44, 46, 48, 49, 50, 53, 54, 55 and 56.

Add the following claims:

13 —~~58~~. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well, echo receiving and registering means coupled to said well to expose said receiving and registering means to pressure variations produced in said well by echoes from said obstructions, and means associated with

Defendant's Exhibit T—(Continued)

and registering

said receiving ∧ means to accent the registration of tubing coupling echoes.

14 —~~59~~. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from couplings and other obstructions in said well, pressure responsive echo receiving and registering means cou-

and registering

pled to said well to expose said receiving ∧ means to pressure variations in said well produced by echoes from said obstructions, and interference eliminating means associated with said receiving and registering

and registering

means for limiting the response of said receiving ∧ means to the registration of echoes from actual obstructions in the well whereby the registered echoes of the tubing couplings may be readily distinguished from each other and from the echoes from other actual obstructions in the well.

15 —~~60~~. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating a pressure impulse in said well to produce echoes of said impulse from the couplings and other obstructions in said well, pressure responsive echo receiving and registering means coupled

Defendant's Exhibit T—(Continued)

to said well to expose said receiving and registering means to the pressure variations produced in said well by echoes from said obstructions, and resonance means associated with said receiving and registering means to produce therein a natural acoustical period of oscillation so related to the frequency of the echoes from the tubing couplings as to accent the registration of the tubing coupling echoes.

16 —~~61~~. In an apparatus for determining the unknown location of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating therein a pressure impulse to produce echoes of said impulse from the couplings and other obstructions in the well, echo receiving and registering means including a pressure responsive device, and pipe means coupling said pressure responsive device to said well to expose said device to pressure variations in the well, and means for adjusting the effective length of said pipe means to produce a natural acoustical period of oscillation of said pressure responsive device so related to the frequency of the echoes of said tubing couplings as to accent the registration of said echoes.

17 —~~62~~. In an apparatus for determining the unknown loaction of an obstruction in a well having a string of assembled tubing sections therein connected by couplings, means communicating with said well for creating therein a pressure impulse to produce echoes of said impulse from the couplings and other obstructions in said well, pressure responsive

Defendant's Exhibit T—(Continued)

echo receiving and registering means having a natural frequency of oscillation so related to the frequency of the echoes from said tubing couplings as to accent the registration of said echoes, and means interconnecting said receiving and registering means to said well to expose said receiving and registering means to pressure variations in said well.—

Claims 24, 25 and 26, Line 7, before "length insert —effective—.

REMARKS

In view of the requirement for division contained in the Office action of February 21, 1939, the applicant has by this amendment limited all of the claims of this application to the apparatus for determining the location of obstructions in wells though the Examiner's attention is called to what is believed to be an inadvertent error in classifying Claims 38, 39, 40 and 41 with the claims indicated as Group II in the requirement for division. Claims 38 through 41, inclusive, are not directed to the calibrating tube mechanism (53, etc.) for measuring the velocity of the impulse in the particular gaseous medium but instead are directed to the receiving device 22 by which the echoes of the impulse are received and registered. It is believed that the Examiner did not intend to group these claims 38 to 41 with Claims 33 through 36, and for this reason these claims have been left in this application.

At the oral interviews had with the Examiner in charge of this application and with the Primary

Defendant's Exhibit T—(Continued)

during the week of February 6, 1939, the several phases of the invention disclosed in this application were thoroughly discussed and it was pointed out to the Examiner that one of the important features of the applicant's device was in so arranging the receiving mechanism that the tubing collar echoes were registered in a manner permitting them to be distinguished one from the other and also from the echoes of other obstructions existing in the well. It was pointed out that this was a feature which was not disclosed in any of the references of record in this application and was considered by the Examiner at these interviews to constitute allowable subject matter.

While allowed Claims 24, 25 and 26 are directed to this subject matter, it was suggested that claims could be presented to this feature which would clearly distinguish from the Batcheller and Lehr, et al patents, and for this reason new Claims 58, 59, 60, 61 and 62 are presented herewith.

Claim 58 defines this subject matter in clear and definite terms specifying all of the necessary elements for accomplishing the result of producing the echoes from the tubing collars which are distinguishable from each other by employing in combination with the receiver, means or mechanism which accents the echoes from the tubing collars.

Claim 59 recites this same structure but in more limited terms, specifying that this means or mechanism for permitting the distinguishable registration of the tubing collar echoes is an "interference

Defendant's Exhibit T—(Continued)

eliminating means" which limits the response of the receiver to the desired echoes and thus prevents interference with these registrations by extraneous disturbances such as harmonics and other reverberations, as specified on Page 20 of the original specification.

Claim 60 defines this same subject matter but limits the mechanism to a "resonance means" which produces a natural acoustical period of oscillation in the receiver so related to the frequency of the echoes from the tubing collars as to accent the registration of the tubing collar echoes.

Claim 61 is still more limited in that it specifies that the receiving means includes a pressure responsive device and also a pipe which couples the pressure responsive device to the well, with means for adjusting the effective length of this pipe to produce the necessary natural acoustical period of oscillation in the receiver.

Claim 62 is likewise directed to this same feature but defines the receiving and registering means as one which has the peculiar characteristic that it has a natural frequency of oscillation which will result in the accenting of the tubing collar echoes.

Upon review of Claims 24, 25 and 26, it is believed that these claims are rendered more accurate and definite by employing the word "effective" to define the adjustment of the length of the pipe or other coupling means employed to tune the receiving means to the tubing collar echoes. This amendment does not change the subject matter defined by these

Defendant's Exhibit T—(Continued)

claims and it is believed that each of them is clearly allowable over the references of record.

Claims 52 and 57 are likewise directed to this same subject matter but expresses the invention in somewhat different terms. Again, however, these claims are directed to the feature of producing distinguishable tubing collar echoes and are believed to be clearly patentable over the references of record.

At this point it is desired to call the Examiner's attention to the fact that the subject matter of each of Claims 52, 57 and 58 through 62 was considered and discussed with the Examiner at the oral interview and that the subject matter was considered to clearly define invention over all of the prior art patents of record as well as all of the art which was then available to the Examiner.

The only remaining claims in this application which have not been considered by the Examiner are Claims 40 and 41, both of these claims being directed to the particular construction of the applicant's pressure responsive device with its housing, together with the light reflecting mechanism so arranged that the light reflecting device may be adjusted from the exterior of the housing. These claims are drawn along the lines of allowed Claims 38 and 39 but include this additional feature of adjustment which has not been found in any of the references of record. It is believed that these claims are clearly allowable.

The attorney for applicant had hoped to be able

Defendant's Exhibit T—(Continued)

to present an amendment along the foregoing lines to the Examiner prior to the entry of an Office action and the amendment was partially prepared before the receipt of the Office action of February 21, 1939. However, the Examiner's prompt action on this application is sincerely appreciated since by this one amendment it is believed that all of the questions raised at the oral interviews have been completely answered and that this application is now presenting only the subject matter which was considered to be allowable.

In view of the fact that this application has been made special, it is requested that an early favorable action be entered in this case.

Respectfully submitted,

HAROLD W. MATTINGLY,

Attorney for Applicant.

HWM:MM

Defendant's Exhibit T—(Continued)

Mailed Mar 21 1939

H. Div. 5

Serial No. 162,699

81

Address only

The Commissioner of Patents

Washington, D. C.

Department of Commerce

United States Patent Office

Washington

March Twenty-one, 1939

Cranford P. Walker

Your Application for a patent for an Improvement in Means for Measuring the Location of Obstructions in Wells filed Sept. 7, 1937 has been examined and Allowed with 17 claims.

The final fee, Thirty Dollars, With $1 Additional for Each Claim Allowed in Excess of 20, must be paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld, but the application may be renewed within one year after the date of the original notice with a renewal fee of $30 and $1 additional for each claim in excess of 20.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be

Defendant's Exhibit T—(Continued)

sent, Distinctly and Plainly Written, the name of the Inventor, Title of the Invention, and Serial Number as Above Given, Date of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names of the Assignees.

If it is desired to have the patent issue to an Assignee or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Notice.—When the Number of Claims Allowed Is in Excess of 20, No Sum Less Than $30 Plus $1 Additional for Each Claim in Excess of Twenty Can Be Accepted as the Final Fee.

Respectfully,

CONWAY P. COE,

Commissioner of Patents.

[Printed in Margin]: In Remitting the Final Fee Give the Serial Number at the Head of This Notice.

[Printed in Margin]: Uncertified Checks Will Not Be Accepted.

Defendant's Exhibit T—(Continued)

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope St.
Los Angeles, Calif.

Apr-3-39 197821 D nCheck—30.00
Walter P. Huntley MAdison 1137
Mail Division Apr 3 1939. U. S. Patent Office.

1/85

Harold V. Mattingly
Attorney at Law
Patent and Trademark Causes
621 South Hope Street
Los Angeles, California
March 30, 1939

Commissioner of Patents
Washington, D. C.

Sir:

Enclosed please find my check No. 1134 in the amount of $30.00, payment of the final Government fee in the matter of the application for United States Letters Patent for Means for Measuring the Location of Obstructions in Wells.

Name of Inventor—Cranford P. Walker
Serial No. 162,699
Filed September 7, 1937
Allowed—March 21, 1939, with 17 claims.

Respectfully,
HAROLD W. MATTINGLY.

MM

Defendant's Exhibit T—(Continued)

Received Apr 6-1939. Division 5, Paper No. 15. Pet (R-78) & Audt G.

Rule 78 Apr 7-1939. Orders No. 2698, 2801, 3311.

Via Air Mail
Confirmation
Regular Mail

U. S. Patent Office, Apr 5-1939. Issue Division.

In the United States Patent Office
Division 5—Room 3077

Cranford P. Walker
Method and Means for
Measuring the Location
of Obstructions in Wells
Filed September 7, 1937
Serial No. 162,699

Los Angeles, California
March 31, 1939

Hon. Commissioner of Patents
Washington, D. C.

Sir:

In the above entitled matter, the following amendment is presented under the provisions of Rule 78:

Claim 41, Lines 12 and 19, change "casing" to read—housing—.

Claim 52, Line 1, cancel "An" and insert—In an—; Line 3, change "the" to read—a—.

Claim 58, Line 10, and Claim 59, Lines 8 and 12, after "receiving" insert —and registering—.

Defendant's Exhibit T—(Continued)

Claim 62, Line 6, change "coupling" to read —couplings—; Line 10, after "echoes" insert—,—.

[Marginal Note]: O. K., C. L. J.

REMARKS

In preparing this case for issue it was noted that in certain of the claims language had been used in the opening part of the claims to define elements which were later referred to by different names. The changes made as indicated will now make these definitions uniform throughout each of the claims. The other changes are to correct obvious grammatical errors.

Applicant respectfully submits that the amendments to these claims render them more accurate but do not alter or change the scope of the claims and will not require additional search.

It is therefore requested that these changes be entered in this application under the provisions of Rule 78.

Respectfully submitted,

HAROLD W. MATTINGLY,

Attorney for Applicant.

HWM:MM

Entered under Order 3311.

L. W. JOHNSTON,

Acting Examiner.

Defendant's Exhibit T—(Continued)

073

Div. 5 Room 3077 Paper No. 16

Department of Commerce
United States Patent Office
Washington

Mailed CLJ/H Apr 7-1939.

Address Only
The Commissioner of Patents
Washington, D. C.

Harold W. Mattingly
924 Pacific Finance Bldg.
621 S. Hope St.
Los Angeles, Calif.

Applicant: Cranford P. Walker
Ser. No. 162,699
Filed Sept. 7, 1937
For Means for Measuring the Location of Obstructions in Wells

Apr. 8, 1939

The amendment proposed under Rule 78 has been entered under authority of Commissioner's Order No. 3311.

L. W. JOHNSTON,
Acting Examiner.

[Printer's Note: Copy of Patent No. 2,156,519, issued to C. P. Walker for Means for Measuring the Location of Obstructions in Wells," attached here, is not reproduced, as it is set out in full as Plaintiff's Exhibit No. 1, in this Book of Exhibits.]

Defendant's Exhibit T—(Continued)

District Court of the United States
Southern District of California—Central Division

Honorable Commissioner of Patents,
Washington, D. C.

Sir:

In compliance with the Act of February 18, 1922 (42 Stat. L. 392), you are advised that there was filed on the 16th day of July, 1941, in this court an action, suit, or proceeding No. 1655-H-Civ., entitled:

Name Cranford P. Walker, etc., et al., Plaintiffs.
Address Los Angeles, California,

versus

Name Halliburton Oil Well Cementing Co., a Delaware corp., Defendant.

Address Los Angeles, California.

brought upon the following patents:

	Patent No.	Date of Patent	Patentee
1.	2,156,519	May 2, 1939	Cranford P. Walker
2.	2,161,733	June 6, 1939	Cranford P. Walker
3.	Reissue 21,383	Mar. 5, 1940	Cranford P. Walker

In the above-entitled case the following decision has been rendered or decree issued:

.....

.....

Defendant's Exhibit T—(Continued)

In Witness Whereof I have affixed my hand this 16th day of July, 1941, at Los Angeles, Calif.

R. S. ZIMMERMAN,
Clerk of said Court.
By L. WAYNE THOMAS,
L. Wayne Thomas, Deputy Clerk.

421
1937

CONTENTS

1. Application.....papers.
2. Print Sept. 11, 1939
3. Rejection Oct. 25/37
4. Amendment Apr. 21/38
5. Rejection June 15/38
6. Amendment B June 17/38
7. Letter Sept. 12/38
8. Amendment C Dec. 12/38
9. Amendment D Dec. 15/38
10. Amendment E Feb. 9/39
11. Let. to Mr. R. Special Feb. 11/39.
12. Com's Div. (Pet. Granted) Feb. 13/39
13. Rejection (Division) Feb. 21/39
14. Amendment F Mar. 6/39
15. Pet. (R-78) & Amdt. G Apr. 6/39
16. Letter (Aprvd.) Apr. 8/39
17. Notice of suit July 21-1941

[Endorsed]: Filed Nov. 10, 1942.

DEFENDANT'S EXHIBIT U

390

Department of Commerce
United States Patent Office

To all persons to whom these presents shall come,
Greeting:

This Is To Certify that the annexed is a true copy from the records of this office of the File Wrapper and Contents, in the matter of the

Letters Patent of
Paul E. Lehr and Harold T. Wyatt,
Number 2,047,974, Granted July 21, 1936,
for
Improvement in Methods and Apparatus for Measuring Well Depths.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this seventh day of November, in the year of our Lord one thousand nine hundred and forty-one and of the Independence of the United States of America the one hundred and sixty-sixth.

Attest:

D. E. WILSON,
Chief of Division.

[Seal] CONWAY P. COE,
Commissioner of Patents.

R.B.

NUMBER (Series of 1933)

696230

1933

PATENT NO. 1,204,974

DATED JUL 21 1936

GRANTED UNDER 1-C-139-1

Name PAUL E. LEHR AND HAROLD T. WYATT

LONG BEACH,
CALIFORNIA

METHOD AND APPARATUS FOR MEASURING OIL WELLS

Drawing

Specification

Claims

Date of Application

Amendment

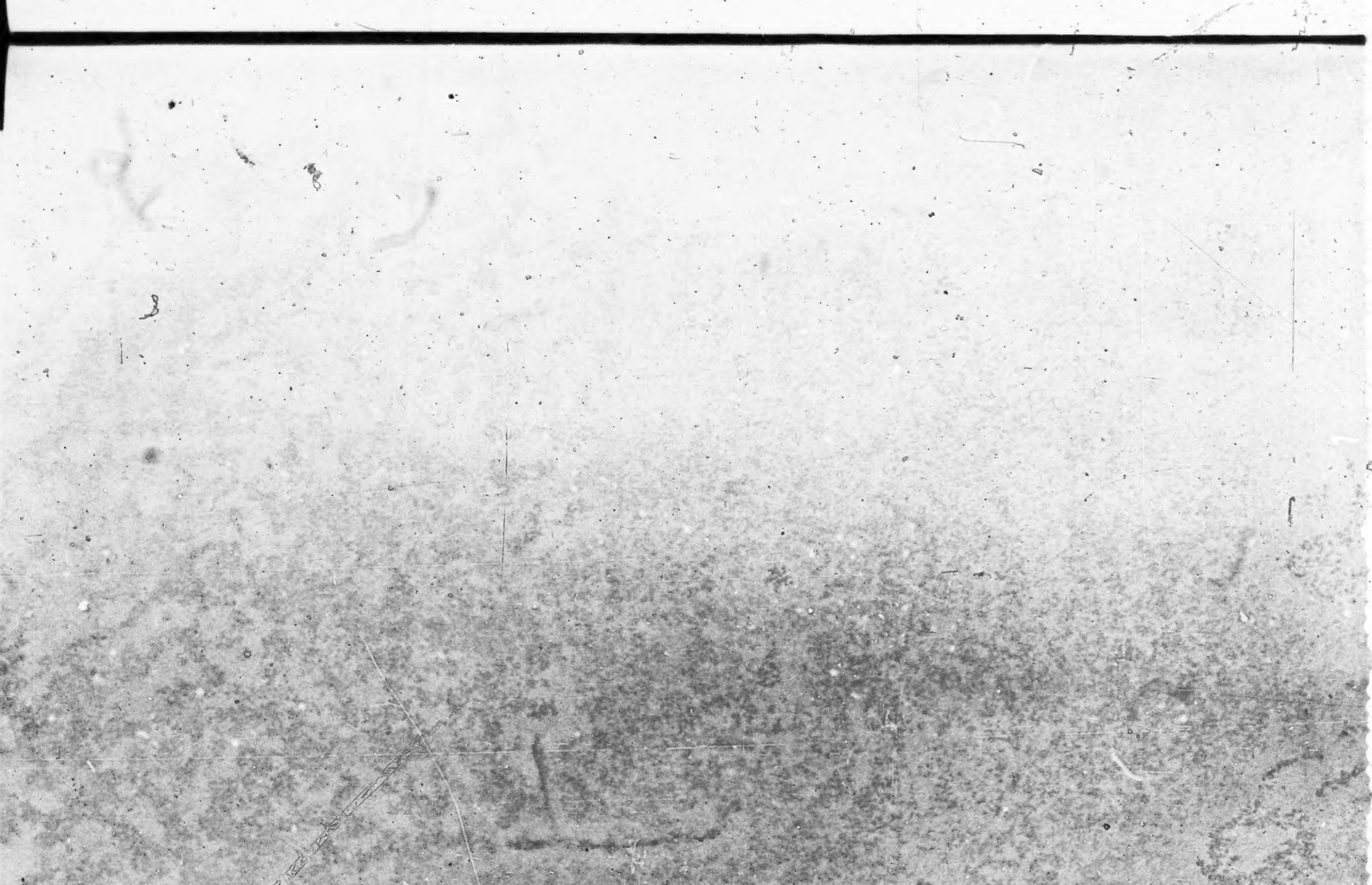
Date of Allowance

Issue Fee

Attorney

ASSIGNOR TO [illegible] OF [illegible] LOS ANGELES CALIF.

Remarks



Defendant's Exhibit U—(Continued)

35/238

Nov-1-33 76340 K - Check — 30.00

Telephone
MIchigan 3901

Law Offices
Lyon & Lyon
Patent and Trade-Mark Causes
National City Bank Building
Los Angeles

Mail Division Nov. 1 33.
U. S. Patent Office.

Frederick S. Lyon
Leonard S. Lyon
Lewis E. Lyon
Richard F. Lyon

Henry S. Richmond
Irwin L. Fuller
Reginald E. Caughey
Casimir A. Miketta
Harold W. Mattingly

Francis D. Ammen
William A. Doble, Jr.
Eugene Woodbury

October 28, 1933

Commissioner of Patents
Washington, D. C.

Sir:

Attached is application for United States Letters Patent executed October 27, 1933 by Harold T. Wyatt and Paul E. Lehr for Method and Apparatus for Measuring Well Depths; also attached is our

Defendant's Exhibit U—(Continued)

check No. 5620 in the amount of $30.00 to cover the Government filing fee. (10 claims).

Respectfully,

LYON & LYON

EP
Enc

Mail Division Nov - 1 33 U. S. Patent Office.

PETITION AND POWER OF ATTORNEY

To the Hon. Commissioner of Patents:

Your petitioners, Paul E. Lehr and Harold T. Wyatt, citizens of the United States, residing at Long Beach, in the County of Los Angeles, and the State of California, whose post-office address is c/o Shell Oil Company, Higgins Building, Los Angeles, California, pray that letters patent may be granted to them for the Method and Apparatus for Measuring Well Depths set forth in the annexed specification, and they hereby appoint the firm of

Lyon & Lyon

(the individual members of which firm are Frederick S. Lyon, Leonard S. Lyon and Lewis E. Lyon), 708 National City Bank Building, Los Angeles, California, their attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

Defendant's Exhibit U—(Continued)

Inventor sign full name:

HAROLD T. WYATT
PAUL E. LEHR

Specifications

To All Whom it May Concern

Be it known that

We, Paul E. Lehr and Harold T. Wyatt, residing at Long Beach, in the County of Los Angeles and State of California, have invented a new and useful

Method and Apparatus for
Measuring Well Depths

of which the following is a specification:

This invention relates to a method and apparatus for measuring distances and while the invention may be employed for different specific purposes, it is intended to be used particularly for measuring the depth of deep wells.

The usual method of measuring a well depth is by means of a sand line or a similar line let down onto the well. This consumes considerable time and labor.

It has been attempted to measure the depth of wells by using a sound wave method in accordance with which a sound is made at the mouth of the well and then the elapsed time is measured for this sound wave to pass to the bottom of the well and be reflected back to the mouth of the well. The sound wave method operates more perfectly in the-

Defendant's Exhibit U—(Continued)

ory than in practice for the reason that there is really very little energy in a sound wave and in deep wells this energy becomes so dissipated that the recording of the elapsed time becomes difficult. In using the sound method referred to, perhaps the crookedness of the well hole has considerable to do with the dissipation of the energy of the sound, causing considerable reflection and partial absorption of the sound waves as they pass down the well and return.

The general object of this invention is to provide a simple method and simple apparatus for ascertaining the distance to a distant surface from a local point, and particularly the distance from a well head to the liquid surface at the bottom of the well. It is frequently desirable during operations to ascertain the depth of the well measured to the surface of the liquid at its bottom and it is also frequently necessary to have this information in connection with pumping wells. The present method and apparatus affords means for determining well depths without the use of a sand line, and saving considerable labor; and without the use of a "sound method" which is more or less unreliable.

The invention may be practiced to advantage in shut down fields where it is important that a systematic series of fluid level observations be taken in order to locate those wells where the casing has failed and allowed water to enter.

Further objects of the invention will appear hereinafter.

Defendant's Exhibit U—(Continued)

As regards the apparatus, the invention consists in the novel parts and combination of parts to be described hereinafter, all of which contribute to produce an efficient apparatus for measuring well depths.

As regards the method, the invention consists in those novel steps and combinations of steps to be described hereinafter, all of which contribute to produce an efficient method for measuring well depths.

A preferred embodiment of the invention is described in the following specification, while the broad scope of the invention is pointed out in the appended claims.

In the drawings:

Figure 1 is a diagrammatic view illustrating a simple form of apparatus which may be employed in practicing the invention. This view shows some of the apparatus in side elevation and shows a portion of a well casing partly in elevation and partly in section, with certain parts broken away;

Figure 2 is a view similar to Figure 1 but illustrating indicating or recording apparatus for producing a record of the elapsed time in making the test;

Figure 3 is a view similar to Figure 2 but illustrating simple apparatus for enabling the invention to be practiced where the well is under pressure;

Figure 4 is a longitudinal section through a quick

Defendant's Exhibit U—(Continued)

opening valve or cock which may be of conventional type and which is employed in connection with the invention.

Before proceeding to a detail description of this invention, it should be stated that it employs the impulse wave principle, and the impulse wave is not generated by sound, but is generated by causing a sudden change in pressure at the well head. This change in pressure may be occasioned by a sudden liberation of a sufficient quantity of gas at the well mouth to cause a sudden substantial increase of pressure or a sudden decrease of static pressure within the the well head, and it may be accomplished so that only a slight change in pressure at the local point results. In either case this produces a pressure ^ ~~an~~ impulse wave immediately ~~originates~~ at the well head; and the elapsed time is observed for this wave to traverse the space from the local point or well head, to an obstruction such as liquid in the well, and return to the well head. If the well is not under pressure, we prefer to employ a confined quantity of fluid, preferably gas, and suddenly liberate a small quantity of it into the well head.

If the well has considerable pressure in it, as frequently exists in gas wells, the invention can be practiced by allowing a quantity of gas at the well head to escape suddenly into the atmosphere. If this is done, an expansion wave immediately originates at the well head, passes down to the surface of the liquid at the well bottom, and then travels up to the well head.

Defendant's Exhibit U—(Continued)

The elapsed time may be observed or indicated in any desired manner. If it is not desired to employ indicating instruments or recording instruments, a simple outlet can be provided at the well head, and a quantity of gas or air under pressure admitted suddenly into the well head, will, after a sufficient lapse of time, cause a perceptible puff of air or gas at the outlet. The elapsed time from the instant of admitting the gas or air under pressure until the occurrence of the puff at the outlet, will be the time consumed for the impulse wave to travel down and return from the bottom of the well. Such an impulse wave travels at the same velocity as sound, and if the elapsed time has been observed, it is possible, by employing a simple formula, to compute the depth of the well.

Referring more particularly to the parts and especially to Figure 1, 1 indicates a reservoir for any gas, for example, air, under considerable pressure, and this reservoir is connected through a suitable connection 2 with the valves 3, to an impulse chamber 4, being provided with a gauge 5 for indicating its internal pressure. The other end of this impulse chamber is connected through a quick opening valve or cock 6 to the well head or casing head 7. A flow pipe 8 may extend up through this casing head.

At any point on the periphery of the casing head an outlet 9 is provided to the atmosphere.

The valve 6 may be mounted in a pipe connection

Defendant's Exhibit U—(Continued)

10 which can be readily connected to the side of the casing.

In using the apparatus, the valve 6 should be closed and the valves 3 opened to permit a quantity of the compressed air or gas to accumulate in the impulse chamber 4, for example, at a pressure of one hundred pounds per square inch. The valves 3 would then be closed.

In making the test for determining the well depth, the valve 6 would be suddenly opened, thereby permitting a quantity of the compressed air or gas in the chamber to flow into the well head. This will produce an impulse wave which would pass downwardly as indicated by the arrows at the left side of the casing and this wave would eventually impinge upon the surface 11 at the well bottom 12 and would be reflected back toward the head of the well. When the impulse wave, after its reflection by the surface 11, arrives at the well head, a perceptible puff of the air or gas will occur at the outlet 9. This puff can be felt readily simply by holding one's hand in front of the outlet. At the instant that the valve 6 is opened a stop watch is started, and at the instant that the puff is felt at the outlet 9, the stop watch is stopped. The elapsed time will be the time required for the impulse wave to traverse the space from the local point at the well head to the surface 11, and return.

The velocity of this impulse wave will be substantially the same as that of a sound wave and can be computed by the following formula:

Defendant's Exhibit U—(Continued)

$$\text{Velocity} = \frac{Cp}{Cv} \times \frac{P}{D}$$

In this formula Cp equals the specific heat of the gas or air at constant pressure and Cv equals the specific heat of the gas or air at constant volume. The pressure P is usually expressed in pounds per square ft., and the density D of the gas would be expressed in pounds mass per cubic ft. This will express the velocity in ft. per second.

From this formula it is evident that the velocity of the impulse wave is independent of the pressure, for the reason that when the pressure is increased the density is also increased in the same proportion. If very accurate results are necessary, correction for temperature changes may be made according to well-known formulas.

If it is desired to have the result of the test indicated or recorded, this can be accomplished by providing a small pipe connection 13 (see Figure 2) which is attached to the casing 14 instead of the outlet 9, and this connection may carry a micro-

15

phone ~~13~~ which is electrically connected with an indicating or recording instrument 16. If desired, the circuit connection 17 between the microphone and the indicator or recorder 16 may include an amplifier 18 connected to conductors 19 and 20 of an electric power circuit.

The recorder 16 illustrated may be provided with a pen arm 21 which would be controlled by an impulse in the circuit 17, and this pen arm would

Defendant's Exhibit U—(Continued)

carry a pen or pencil 22 to run on the face of a recording drum 23 mounted to rotate on its horizontal axis in bearings 24.

This recording drum would be rotated at a uniform speed when the test was started, and the pen 22 would run in a straight line 25 on the drum and produce a laterally disposed peak in the line when the test started, and when the test ended by the return of the impulse wave from the bottom of the well. The test would be made in the same manner as that described in connection with Figure 1, and the apparatus used would be the same as illustrated at the left side of Figure 2.

If the well is under pressure, the invention can be practiced without the use of a high pressure gas, by merely permitting the quick exit of some of the gas in the well. This is illustrated in Figure 3 in which 26 indicates the well head which is provided at one side with a connection 27 carrying a quick opening valve or cock 28. The casing is provided with a pipe connection 29 carrying a ~~michrometer~~ microphone 30 with circuit wires 31 and 32 connecting it up to an amplifier and recording instrument. In practicing the invention, as illustrated in Figure 3, the sudden exit of a small quantity of gas under pressure from the interior of the head will cause an impulse wave to start from the well head, and thence to the liquid at the bottom of the well; this impulse will return, and the instant of arrival of this impulse wave at the well head 26 will be indicated by

Defendant's Exhibit U—(Continued)

microphone microphone
the ~~michromet~~ The ~~michrometer~~ and its connected indicating and recording instrument would also indicate the instant at which the valve 28 was open, thereby indicating the elapsed time. Hence, in using the formula in this case, also, it will be necessary to bear in mind that the impulse wave travels twice through the length or depth of the well.

In using the term "gas" in this specification and claims, it should be understood that the term, when used in its broad sense, is intended to include air which is, in fact, a gas.

It is understood that the embodiment of the invention described herein, is only one of the many embodiments this invention may take, and we do not wish to be limited in the practice of the invention, nor in the claims, to the particular embodiment set forth.

It is evident that our invention can be practiced also when the casing has atmospheric pressure within it or a partial vacuum, and with the same facility as when the well is under a high pressure.

What We Claim Is:—

~~1. A method of measuring the distance from a~~ local point to the surface of a distant object through maintaining a confined
a fluid medium which consists ∧ ~~in confining~~ a supply ~~of fluid under pressure, suddenly liberating a suffi-~~

Defendant's Exhibit U—(Continued)

~~cient quantity of the confined fluid at the local point~~, to cause a substantial change in the pressure at the local point and thereby producing ^ a pressure impulse wave in said medium due to the difference of pressure, and observing the elapsed time for the impulse wave to traverse the space between the local point and the object and return to the local point.

2. A method of measuring the distance to an obstruction or liquid in a well, which consists ^ maintaining a confined supply of gas under pressure ~~in confining gas~~ at the well's mouth, suddenly liberating a quantity of the said gas under pressure ^ at ~~into or out of~~ the well mouth and thereby producing a substantial change in pressure and an impulse wave in the gas in the well, and observing the elapsed time for the impulse wave to traverse the space from the head of the well to the obstruction, and ~~back again to the well's mouth~~.

~~1~~ 3. A method of measuring the depth of a well having a casing head and casing, which consists in (^B') ~~maintaining a confined supply of gas under pressure at the well head,~~ suddenly admitting a quantity of the said gas under pressure into the casing head and thereby producing a substantial change in static pressure and an impulse wave in the gas or air within the casing, ~~and observing the~~ elapsed time for the impulse wave to traverse the space from the casing head to the bottom of the well and back again to the casing head.

Defendant's Exhibit U—(Continued)

24. A method of measuring the depth of a well having a casing head and casing, which consists in confining a quantity of gas under pressure in the casing head, suddenly liberating a quantity of said gas and suddenly reducing the static pressure in the casing head and thereby producing an impulse wave in the gas within the casing, and observing the elapsed time for the impulse wave to traverse the space from the casing head to the well bottom and back to the casing head.

25. In apparatus for measuring the depth of a well, the combination of an impulse chamber ~~for~~ carrying a gas maintained under pressure, a connection from the impulse chamber to the ~~interior~~ head of the well including a quick opening valve, said well having an outlet to the atmosphere, said parts cooperating so that when the valve is suddenly opened, a ~~quantity of~~ portion of the gas under pressure will pass into the well and thereby raise the static pressure of the gas at the head of the well to produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, said impulse wave operating to produce a puff of gas at said outlet when the impulse wave arrives at the well head, ~~and~~ thereby enabling the elapsed time ~~for the wave to traverse the space to the well bottom,~~ during the wave's travel, to be observed.

Defendant's Exhibit U—(Continued)

4 ~~6~~. In apparatus for measuring the depth of a well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure at the earth's surface, a connection from the impulse chamber to the head ~~interior~~ of the well including a quick opening valve, said well having an outlet to the atmosphere, said parts cooperating so that when the valve is suddenly opened, a portion of the ^ ~~quantity of~~ gas under pressure will pass into the well and thereby cause an increase of static pressure in the gas in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, and means for indicating the elapsed time for the wave to traverse the space to the well bottom and return ^ ~~back again to the surface~~.

5 ~~7~~. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure at the earth's surface, a connection from the impulse chamber to the head ~~interior~~ of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the ^ ~~quantity of~~ gas under pressure will pass into the well and thereby cause a rise in the static pressure in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, and means connected with the well for indicating the

Defendant's Exhibit U—(Continued)

elapsed time for the wave to traverse the space to return the well bottom and ^ ~~back again~~ to the surface.

6 ~~8~~. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure, a connection from the impulse chamber to the interior of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, portion of the a ^ ~~quantity of~~ gas under pressure will pass into the well and thereby cause a rise in the well head static pressure, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, and a microphone connected with the well for indicating the instant the wave completes its travel within the well.

7 ~~9~~. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure, a connection from the impulse chamber to the interior of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the ^ ~~quantity of~~ gas under pressure will pass into the well and thereby raise the static pressure in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, a microphone connected with the well, and a recording device electrically connected with the microphone.

Defendant's Exhibit U—(Continued)

8 ~~10~~. In apparatus for measuring the depth of a closed well, the combination of an impulse chamber ~~for~~ carrying a gas under pressure, a connection from the impulse chamber to the interior of the well including a quick opening valve, said parts cooperating so that when the valve is suddenly opened, a portion of the ^ ~~quantity of~~ gas under pressure will pass into the well and thereby raise the static pressure in the well head, and produce an impulse wave passing to the bottom of the well and reflected back to the head of the well, a microphone connected with the well, an indicating device electrically connected with the microphone, and an amplifier between the microphone and the indicating device cooperating to indicate the elapsed time for the wave to traverse the space to the well bottom.

Signed at Los Angeles, Calif. this 27th day of Oct., 1933.

Inventor sign full name:

HAROLD T. WYATT
PAUL E. LEHR

OATH

State of California
County of Los Angeles—ss.

Paul E. Lehr and Harold T. Wyatt, the above named petitioners, being duly sworn, depose and say that they are citizens of the United States, and residents of Long Beach, California; that they verily believe themselves to be the original, first and

Defendant's Exhibit U—(Continued)

joint inventors or discoverers of the Method and Apparatus for Measuring Well Depths described and claimed in the annexed specifications; that they do not know and do not believe that the same was ever known or used before their invention or discovery thereof, or patented or described in any printed publication in any country before their invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on an application filed by them or their legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said invention has been filed by them or their legal representatives or assigns in any country foreign to the United States.

Inventor sign full name:

HAROLD T. WYATT

PAUL E. LEHR

Subscribed and sworn to before me, this 27th day of October, 1933.

(Seal) H. S. ST. CLAIR

Notary Public in and for the County of Los Angeles, State of California.

My Commission Expires March 20, 1935.

V-3526 696290 1564

974

Print of drawing as originally filed.

Fig 1.

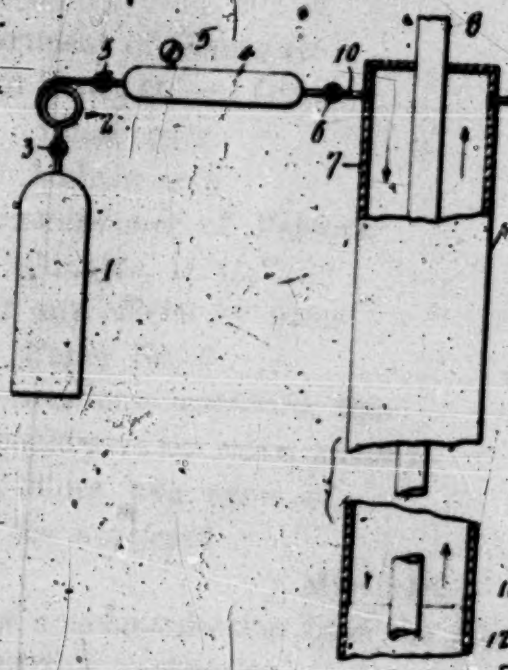
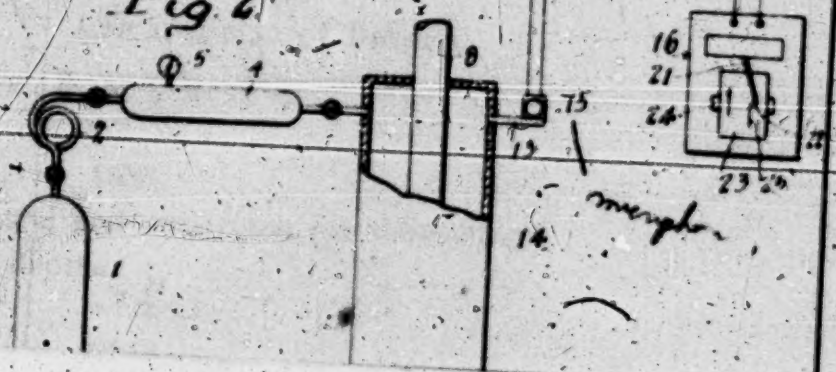
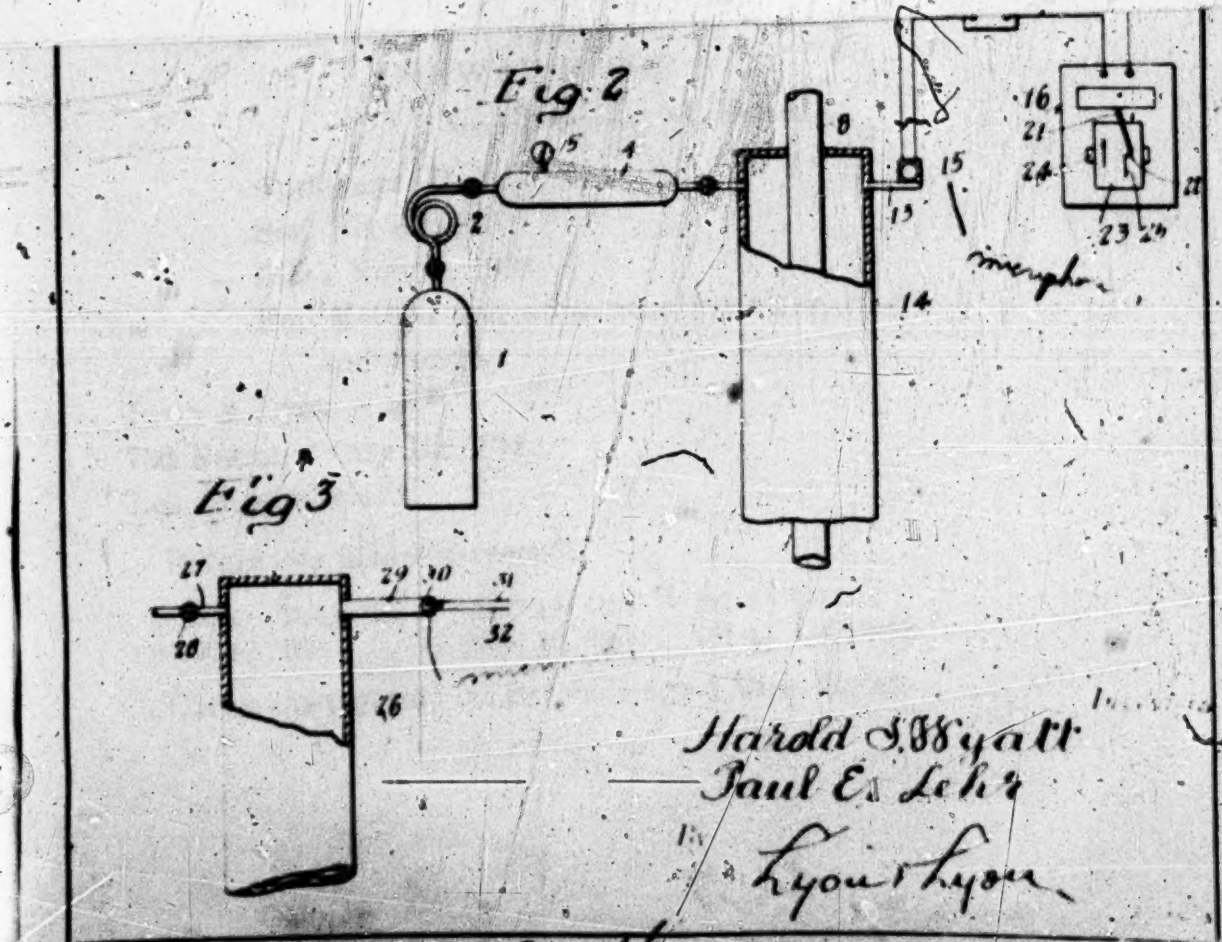


Fig 4

Fig 2.





42 696290 16

Defendant's Exhibit U—(Continued)

260

Div. 42 Room 5882

Department of Commerce
United States Patent Office
Washington
Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name
Paper No. 3
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Mar 8 1934

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE
Commissioner of Patents.

Applicant: P. E. Lehr et al
Ser. No. 696,290
Filed Nov. 1, 1933
For Method and apparatus for measuring
well depths

Lyon & Lyon
708 National City Bk. Bldg.
Los Angeles, Calif.

References made of record:

602,422	Batcheller	Apr. 19, 1898	181-0.5 (386.1x
1,889,614	Rice	Nov. 29, 1932	181-0.5 (352.5x.52

Claim 1 is rejected on Batcheller and Rice. Batch-

Defendant's Exhibit U—(Continued)

eller produces an impulse wave by suddenly producing a pressure. It would not be invention in Batcheller to produce the impulse wave by a sudden release of pressure in view of the disclosure of Rice.

Claim 2 is rejected as alternative since it is drawn to the modification of Figs. 1 or 2 or the modification of Fig. 3.

Since the generic claims are unpatentable division is required between:

I—claims 3 and 5 through 10 drawn to the modification of Figs. 1 or 2 and

II—claim 4, drawn to the modification of Fig. 3.

Should applicant insist upon the patentability of any generic claims either as now presented or in different form, the response, to be complete, must include an election of the species it is desired to retain in the event that generic claims are not finally found to be allowable. (Ex parte Doane, 410 O. G. 275).

H. O. CUTTING
Examiner

LCL
lcl;v

Defendant's Exhibit U—(Continued)

Mail Division Aug 20-34 U. S. Patent Office. Division 42, Paper No. 4. Aug 21 1934 U. S. Patent Office.

In the United States Patent Office
Division 42—Room 5882

In re application of
Paul E. Lehr, et al,

METHOD AND APPARATUS FOR MEASURING WELL DEPTHS,

Serial No. 696,290,
Filed November 1, 1933.

Los Angeles, California,
August 15, 1934.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Replying to the Examiner's letter of March 8, 1934, amendment is hereby made as follows:

Page 4, line 10, after "sudden" insert —liberation of a sufficient quantity of gas at the well mouth to cause a sudden substantial—; same page, line 11, after "pressure" and before the comma, insert —within the well head—; same page, line 13, strike out "an" and substitute —this produces a pressure—; same page, line 14, strike out "originates".

Claim 1, line 3, strike out "in confining a" and substitute —maintaining a confined—; line 4, before "quantity" insert —sufficient—; line 5, after the comma, insert —to cause a substantial change in the pressure at the local point—; line 6, strike

Defendant's Exhibit U—(Continued)

out "an" and substitute —a pressure—; same line, after "medium" and before the comma, insert —due to the difference of pressure—.

Claim 2, lines 2 and 3, strike out "in confining gas" and substitute —maintaining a confined supply of gas under pressure—; same claim, line 3, place a comma after "mouth"; line 4, before "gas" insert —said—; same claim and line, strike out "into or out of" and substitude —at—; line 5, before "an" insert —a substantial change in pressure and—.

Claim 3, line 2, after "in" insert —maintaining a confined supply of gas under pressure at the well head,—; line 3, before "gas" insert —the said—; line 4, before "an" insert —a substantial change in pressure and—.

REMARKS

The references cited by the Examiner have been carefully studied. The patent to Batcheller seems to applicant to be the only one of any importance on the question of novelty, and this patent employs an entirely different idea of means for attaining applicants' result. Before filing this application, applicants were quite familiar with the Batcheller method, but in using it in actual practice in making well tests, it was not found satisfactory for the reason that there is not enough energy in the sound waves produced, to enable them to give satisfactory results in deep wells, and particularly in crooked wells, because there is so much reflection of the

Defendant's Exhibit U—(Continued)

sound by the walls of the well. Furthermore, the firing of an explosive material such as gun powder into the head of an oil well, is accompanied by considerable risks from fire. Applicants' method and apparatus operate on an entirely different principle, and they do not employ sound waves for attaining the result. In applicants' method they maintain a supply of gas under pressure, either in the well head, or adjacent the well head, and then they suddenly liberate a sufficient quantity of gas under pressure, either into the well head, or out of it, to cause a substantial change in pressure within the well head. This causes an impulse wave (not a sound wave) that passes down to the bottom of the well, and is reflected back again. This invention can be practiced without any danger whatever, of fire, and has been found in practice to give very satisfactory results.

While applicants consider that all of the claims, as last presented, are clearly allowable, nevertheless, it seemed advisable to make some amendments in Claims 1 to 3, so as to prevent any possibility of these claims reading in terms on the Batcheller method. In connection with the amendments to these claims, the Examiner should note that these claims refer to maintaining a confined supply of gas under pressure. Batcheller does not do this. He merely makes a noise at the mouth of the well by means of a firearm. Batcheller's method is based on making a loud noise, and while a small quantity of gas from the explosion is admitted into the well head,

Defendant's Exhibit U—(Continued)

this gas is of relatively small quantity, and does not, as in applicants' method, substantially change the static pressure within the well head.

For these reasons the claims as now amended, are considered clearly allowable.

Claim 2 has been amended to overcome the objection which the Examiner made.

In view of the wording of the amended claims, aplicants still consider that generic claims covering both forms of the invention, are patentable to applicants. For this reason no division in the application has been made, and the Examiner is requested to withdraw his requirement as to this. However, for the Examiner's information, applicant now elects the embodiment of the invention as covered by the claims, which do not include Claim 4.

The patent to Rice does not appear to applicants to be even relevant. It is true that it does involve the idea of reflecting a sound to an airplane from the earth, but it does not involve a method in which a supply of gas under pressure, is maintained at a well head, and this pressure changed suddenly so as to produce a pressure wave.

In view of these explanations and amendments, the Examiner is now requested to pass the application to formal allowance.

Respectfully submitted,

LYON & LYON

Attorneys for Applicant

FDA:LM

Defendant's Exhibit U—(Continued)

260

Div. 42 Room 5882

"Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name.

Paper No. 5

All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Department of Commerce
United States Patent Office
Washington

Dec 14 1934

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE
Commissioner of Patents.

Lyon and Lyon
708 National City Bank Bldg.
Los Angeles, Calif.

Applicant: P. E. Lehr et al
Ser. No. 696,290
Filed Nov. 1, 1933
For Method and apparatus for measuring well depth.

Responsive to amendment filed Aug. 20, 1934.

Upon careful reconsideration claim 1 is rejected as clearly met by Rice. In this reference the valve 8

Defendant's Exhibit U—(Continued)

suddenly liberates a sufficient quantity of confined fluid at the local point to cause a substantial change in the pressure at the local point. This produces a pressure impulse wave in said medium due to the difference in pressure. The other steps in the claim are clearly present in the disclosure of the reference.

Claims 2, 3 and 5 thru 10 are rejected on Batcheller and Rice for reasons given in the last office letter in the rejection of claim 1. The distinction between a sound wave and a pressure impulse is not apparent. A sound wave is nothing more than a pressure impulse wave. It is obvious that Batcheller utilizes the same type of wave that the applicant does irrespective of what he calls it. The wave of Batcheller is produced by the sudden liberation of a quantity of gas.

Since the generic claims are still believed to be unpatentable an action on the merits of claim 4 is not given at this time.

H. MARAA
Acting Examiner

L.C.L.
lcl;v

Defendant's Exhibit U—(Continued)

Application Div. U. S. Patent Office. Jun 12 35.

Division 42, Paper No. 6. Jun 13 1935. U.S. Patent Office.

In the United States Patent Office
Division 42—Room 5882

In re application of
Paul E. Lehr, et al,
Method and Apparatus for Measuring Well Depths,
Serial No. 696,290,
Filed November 1, 1933.

Los Angeles, California,
June 4, 1935.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Replying to the Examiner's letter of December 14, 1934, amendment is hereby made as follows:

Page 4, line 11, before "pressure" insert —static —.

Cancel Claim 1, and substitute the following claim to take its place:

B1

~~11. A method of measuring the distance from a~~ local point to the surface of a distant object through a fluid medium which consists in maintaining a confined supply of fluid under pressure, suddenly liberating a sufficient quantity of the confined fluid at the local point, to cause a substantial change in the static pressure at the local point and thereby producing a ~~pressure impulse wave in said medium due to the~~

Defendant's Exhibit U—(Continued)

~~change of pressure, and observing the elapsed time~~ for the impulse wave to traverse ~~the~~ space between the local point ~~and~~ the object and return to the local ~~point.—~~

Cancel Claim 2 and substitute the following claim to take its place:

B2

9 ~~12~~. A method of measuring the distance to an obstruction or liquid in a well, which consists in maintaining a confined supply of gas under pressure at the well's mouth, suddenly liberating a quantity of the said gas under pressure at the well mouth and thereby producing a substantial change in static pressure and an impulse wave in the gas in the well, and observing the elapsed time for the impulse wave to traverse the space from the head of the well to the obstruction, and back again to the well's mouth.

Claim 3, ~~line~~ 2, strike out the matter inserted by amendment heretofore in this line, and substitute the following therefor:

B3

—maintaining a confined supply of gas under pressure at the well head on the exterior of the casing,— same claim, line 4, strike out the matter inserted in this line heretofore, and substitute the following therefor: —a substantial change in static pressure and—.

Claim 4, line 3, before "gas" insert —quantity of—; line 4, after "thereby" insert —suddenly re-

Defendant's Exhibit U—(Continued).

ducing the static pressure in the casing head and—; same claim, line 5, place a comma after "casing".

Claim 5, line 2, strike out "for"; line 3, after "gas" insert —maintained—; line 4, change "interior" to —head—; line 7, strike out "quantity of gas" and substitute —portion of the gas—; line 8, after "thereby" insert —raise the static pressure of the gas at the head of the well to—; line 12, place a comma after "head"; strike out "and" and substitute —thereby—; same claim, line 13, strike out all of this line except the comma, and substitute —during the wave's travel—.

Claim 6, line 2, strike out "for"; line 4, change "interior" to —head—; line 8, strike out "quantity of" and substitute —portion of the—; line 9, after "thereby" insert —cause an increase of static pressure in the gas in the well head, and—; same claim, strike out the last line and substitute —and return—.

Claim 7, line 3, strike out "for"; line 5, change "interior" to —head—; line 7, strike out "quantity of" and substitute —portion of the—; line 8, after "thereby" insert —cause a rise in the static pressure in the well head, and—; last line, strike out "back again" and substitute —return—.

Claim 8, line 3, strike out "for"; lines 6 and 7, strike out "quantity of" and substitute —portion of the—; line 8, after "thereby" insert —cause a rise in the well head static pressure, and—.

Claim 9, line 3, strike out "for"; line 6, strike out "quantity of" and substitute —portion of the—;

Defendant's Exhibit U—(Continued)

same claim, line 7, after "thereby" insert —raise the static pressure in the well head, and—.

Claim 10, line 3, strike out "for"; line 6, strike out "quantity of" and substitute —portion of the; same claim, line 7, after "thereby" insert —raise the static pressure in the well head, and—.

REMARKS

The references cited by the Examiner have been carefully restudied. In view of the importance of this invention, a personal interview with the Examiner by associate counsel is requested, as it is believed that such an interview should save time in advancing the application toward allowance.

Applicant considers that a sound wave is not merely a pressure impulse wave. A sound wave is a series of compressions and rarefractions. Furthermore, a sound wave has very little energy. It is pointed out in applicants' specification at the time of filing this application, that sound waves have been found to be unsatisfactory for determining the depth of deep wells, due to the fact that sound waves have so little energy. In this connection the Examiner is reminded that deep wells are not straight, and a sound wave descending in a well is subject to many reflections during which a large part of the energy of the wave is absorbed. In both of the references cited, a sound wave is employed for determing the distance to the surface on which the wave is reflected. Applicants' method and apparatus involves a different idea of means for accomplishing that re-

Defendant's Exhibit U—(Continued)

sult. In accordance with applicants' method, there is an actual sudden raising or lowering of the static pressure in the well head, and applicants' method is readily controllable so as to vary the change of pressure at the well head to correspond with the energy required to determine the depth of the well, whatever that depth may be. The Batcheller method of discharging a revolver in the casing is objectionable because it increases a fire hazard; and furthermore, it does not develop a sound wave of sufficient energy to insure effective results in a very deep well, and particularly a crooked well.

Furthermore, applicants' attorneys do not consider that the claims can be read fairly on the Batcheller construction or method. However, in order to enable the claims to distinguish even more clearly, they have been amended to bring out the fact that in applicants' method and apparatus, a portion only of the confined gas is released either into the casing or out of the casing. Applicants' attorneys do not consider that the revolver shown in the Batcheller patent is a means for maintaining a supply of confined gas. It is a means for suddenly generating a sound. And applicants' attorneys object to the use of this revolver as the equivalent of means for maintaining a supply of gas at the well head. It is believed, however, that by reason of the amendments made above, the claims distinguish very clearly from this reference, and also from the reference Rice. In the Rice patent, the operation of the apparatus depends upon the generating of a sound at the air-

Defendant's Exhibit U—(Continued)

plane, and involves the necessity for employing a special receiving apparatus in which all sounds are tuned out except the desired sound which is generated to be reflected by the earth below the plane. This is certainly an idea of means totally different from those employed by the applicants. There is no generation of a pressure wave that raises the static pressure. The apparatus shown by Rice is not considered in any sense the equivalent of applicants' apparatus. It operates on a different principle, and is a complicated apparatus involving the use of selective sound reducing apparatus. Applicants' attorneys consider that the rejection of the claims on these references is very far fetched, and in this connection the Examiner is reminded that one means is not the equivalent of another means unless it operates in the same way to attain the same result. Applicants means is radically different from either of the means used by Batcheller or Rice, and applicants have invented a very simple apparatus and method, which will operate very effectively for measuring well depths. The Examiner is reminded that the patent law is intended to foster the making of improvements such as this, which use simpler means for attaining improved results over the results that have already been attained by prior inventors.

Although applicants' attorneys consider that the means employed by applicants is a radically different means from that disclosed in the references, attention is called to Aeolian Co. vs. Cunningham Piano Co., 251 F. 301, (affirmed in 255 F. 897). The

Defendant's Exhibit U—(Continued)

lower Court used the following language quoted from page 301 of Vol. 251 of the Federal Reporter:

> "Whenever a new thought of real value is thus brought into combination with some means by which the thought is given physical expression, the combination is patentable, although the means may by itself show limited novelty, or even be such as that by itself it would not be patentable. This principle is well established, and we do not understand it to be in dispute. A reference to the cited case of Miehle v. Whitelock, 223 Fed. 647, 139 C.C.A. 201, is a sufficient confirmation of it."

In connection with the case just cited, it will be noted that the effect of the invention is more important than the means actually employed if a new or improved result is attained, as it is in the present case. For the Examiner's convenience, the case just cited will be found in Underwood's Cards 3660-M, Card 154.

Attention is also called to Beldam vs. Garlock Packing Co., 29 F. (2d) 673; 384 O.G. 247, which held that:

> "We must always bear in mind that patented devices are different in the sense of the patent law when they perform different functions, or in a different way, produce a substantially different result."

Referring again to the patent to Rice, it may be true that the Rice apparatus involves the liberation

Defendant's Exhibit U—(Continued)

of a confined fluid at the local point. But the function of the liberating of this fluid is to produce a sound, and it is the sound wave that is employed to determine the distance from the earth. There is no substantial increase in static pressure at the local point, except just at the nozzle where the confined fluid is liberated. There is no wave developed by the static pressure except a sound wave, and the sound wave is the only one that can be employed by the Rice apparatus, involving as it does, a complicated sound receiving apparatus that tunes out all sounds except the desired sound.

The Examiner's attention is also called to a recent case, Gordon Form Lathe Co. vs. Walcott Machine Co., 32 F. (2d) 55, which held that:

> "Patents cannot be considered as anticipations, which do not disclose purpose, means, and mechanism for accomplishing the end of the patent in suit, and which are restricted to a substantially different and limited purpose."

This case is also cited in Underwood's Cards 3660-D, Card 155, and at 17 Pat. Q. 60.

Attention is also called to Wach vs. Coe, Commissioner of Patents, 453 O. G., 463, holding that a combination of old elements with a new mode of operation, is patentable. As pointed out above, the mode of operation of applicants' method and apparatus is radically different from that of the references involving the employment of a simple static pressure wave operating without making of any

Defendant's Exhibit U—(Continued)

sound, or relying upon a weak sound wave for its success.

In view of the above amendments and these explanations, a formal allowance of this application is now respectfully requested.

Respectfully submitted,
LYON & LYON,
Attorneys for Applicants.

_____,
Associate Counsel.

FDA:LM

_____

Commissioner of Patents.
260

Div. 42 Room 5882

Department of Commerce
United States Patent Office
Washington

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Washington, D. C.,"
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Paper No. 7
All communications respecting this
application should give the serial number,
date of filing, and name of
the applicant

Defendant's Exhibit U—(Continued)

Aug 20 1935.

Please find below a communication from the Examiner in charge of this application.

CONWAY P. COE,

Lyon and Lyon
708 National City Bk. Bldg.
Los Angeles, Calif.

Applicant: P. E. Lehr et al
Ser. No. 696,290
Filed Nov. 1, 1933
For Method and apparatus for measuring well depts

Responsive to amendment filed June 12, 1935.

In the drawings the following elements should bear legends such as those indicated, element 1 "source of fluid pressure", element 6 "quick acting valve", element 9 "outlet", elements 15 and 30 "microphone", element 18 "amplifier", element 16 "recorder". These requirements are in accord with ex parte Good 164 O. G. 739 which brings out that the drawings wherever possible should be so complete as to tell the story in the absence of the specification.

Page 7, line 22, "13" should be —15—.

Page 8, line 22, page 9, line 2, "micrometer" is incorrect.

Claims 3 thru 10 and 12 are allowable as at present advised.

Claim 11 is rejected as broader than the invention. The applicant has not shown that the matter

Defendant's Exhibit U—(Continued)

claimed could be used to measure distance in space. In fact he has not shown that it can be used to measure a distance other than the distance to an obstruction in a tube. In the absence of such a showing the claim is clearly broader than the invention for reasons set forth in ex parte Langmuir, 10, Pat. Q. 113 ex parte Opdyke 1890 C. D. 39, ex parte Aram 1926 C. D. 47 and ex parte Tabb 1926 C. D. 107.

Prompt response is urged in view of the condition of the case.

H. O. CUTTING,
Examiner.

LCL
lcl:v

Paper No. 8

Mail Division Sep 23 1935 U. S. Patent Office.

In the United States Patent Office
Division 42—Room 5882

In re application of
Paul E. Lehr, et al,
Serial No. 696,290,
Method and Apparatus for
Measuring Well Depths,
Filed November 1, 1933.

Defendant's Exhibit U—(Continued)

Los Angeles, California,
September 17, 1935.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Please amend the drawing in the above-entitled case, by adding legends to the different parts as indicated in the print of the drawing filed herewith. Add reference numeral to Fig. 4 as shown in the print.

Remarks

If there is any charge for adding these legends to the drawing, please charge the same to the Miscellaneous Fees account of Lyon & Lyon.

Respectfully submitted,
LYON & LYON,
Attorneys for Applicant.

Approved Sept 24, 1935 LCL.
Received in Div. C Sep 26 1935.
Correction Ordered Oct. - 3 1935 Account.
Div C Corrected Oct - 3 1935.
Print Returned by Drafting Div.
FDA:LM

Paper No. 9
Mail Division Sep 23 1935 U. S. Patent Office.
In the United States Patent Office
Division 42—Room 5882

Defendant's Exhibit U—(Continued)

In re application of
Paul E. Lehr, et al,
Serial No. 696,290,
Method and Apparatus for
Measuring Well Depths,
Filed November 1, 1933.

Los Angeles, California,
September 17, 1935.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Replying to the Examiner's letter of August 20, 1935, amendment is hereby made as follows:

Page 7, line 22, change "13" to —15—.

Page 8, line 22, strike out "michrometer" and substitute —microphone—.

Cancel Claim 11.

Remarks

Claim 11 has been canceled, and an amendment to the drawing is filed herewith, and as soon as the drawing has been corrected in accordance with the amendment, this application should be in condition for formal allowance.

The corrections in the specification suggested by the Examiner have been made.

Respectfully submitted,
LYON & LYON,
Attorneys for Applicant.

FDA:LM

Defendant's Exhibit U—(Continued)

[Printed in Margin]: In Remitting the Final Fee Give the Serial Number at the Head of This Notice.

[Printed in Margin]: Uncertified Checks Will Not Be Accepted.

Serial No. 696,290.

42-5882

Address Only

The Commissioner of Patents

Washington, D. C.

Department of Commerce

United States Patent Office

Washington October Thirty, 1935.

Paul E. Lehr and Harold T. Wyatt

Your Application for a patent for an Improvement in Method and Apparatus for Measuring Well Depths filed Nov. 1, 1933 has been examined and Allowed with 9 claims.

The final fee, Thirty Dollars, with $1 Additional for Each Claim Allowed in Excess of 20, must be paid not later than Six Months from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld, but the application may be renewed within one year after the date of the original notice with a renewal fee of $30 and $1 additional for each claim in excess of 20.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work

Defendant's Exhibit U—(Continued)

will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, Distinctly and Plainly Written, the name of the Inventor, Title of the Invention, and Serial Number as Above Given; Date of Allowance (which is the date of this circular), Date of Filing, and, if assigned, the Names of the Assignees.

If it is desired to have the patent issue to an Assignee or Assignees, an assignment containing a Request to that effect, together with the Fee for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of Ten Cents Each. The money should accompany the order. Postage stamps will not be received.

The final fee will Not be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Notice.—When the Number of Claims Allowed Is in Excess of 20, No Sum Less than $30 Plus $1 Additional for Each Claim in Excess of Twenty Can Be Accepted as the Final Fee.

Respectfully,

CONWAY P. COE,

Commissioner of Patents.

Lyon and Lyon
708 National City Bk. Bldg.
Los Angeles, Calif.

Defendant's Exhibit U—(Continued)

Attorney's Room Jan 27 1936 U. S. Patent Office.

Issued Oct. 30, 1935.

U. S. Patent Office Jan 29 1936 Issue Division.

In the United States Patent Office

Paper No. 10

In re application of
Harold T. Wyatt and
Paul E. Lehr,
Method and Apparatus for
Measuring Well Depths,
Serial No. 696,290,
Filed November 1, 1933.

POWER TO INSPECT THE FILE

Los Angeles, California,
January 22, 1936.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Please permit Bernard J. Gratama, Register No. 12,728, to inspect the file of the above indicated application at any time, and to make copies of the papers in said file or any part thereof.

Respectfully submitted,
LYON & LYON,
Attorneys for Harold T. Wyatt and Paul E. Lehr.

Defendant's Exhibit U—(Continued)

Apr. 24, 36 198432 E 2 Check—30.00

35/238

Telephone
MIchigan 3901
Law Offices
Lyon & Lyon
Patent and Trademark Causes
811 West Seventh Street
Los Angeles

April 20, 1936.

[Pencil Notation]: Suspend

Mail Division Apr 24 1936 U. S. Patent Office.

Frederick S. Lyon
Leonard S. Lyon
Lewis E. Lyon
Richard F. Lyon

Henry S. Richmond
Irwin L. Fuller
Reginald E. Caughey
Casimir A. Miketta
Harold W. Mattingly

Francis D. Ammen
William A. Doble, Jr.
Eugene Woodbury

Commissioner of Patents
Washington, D. C.

Sir:

Attached is our check No. 6756 in the amount of $30.00 which please apply to payment of the final Government fee in the United States patent appli-

Defendant's Exhibit U—(Continued)

cation of Paul E. Lehr and Harold T. Wyatt, Serial No. 696290, filed November 1, 1933 for Method and Apparatus for Measuring Well Depths, which was allowed October 30, 1935 with 9 claims.

It is respectfully requested that issue of the patent be deferred for a period of Ninety (90) days.

Respectfully,

LYON & LYON.

Kindly Note Change of Our Address to 811 West Seventh Street Building, Los Angeles.

July 21/36.

LP

Enc

Address Only

The Commissioner of Patents

Washington, D. C.

Department of Commerce

United States Patent Office

Washington

April 27, 1936

Lyon & Lyon

811 West Seventh Street Bldg.,

Los Angeles, California

Applicant Lehr, Paul E. & Wyatt, Harold T.

Serial No. 696290

Filed November 1, 1933

For Method and apparatus for measuring well depths.

Final Fee April 24, 1936

Issue Date July 21, 1936

Defendant's Exhibit U—(Continued)

Sir:

Your letter requesting deferment under Section 4885 R. S. has been received.

Respectfully,

J. A. BREARLEY,

J. A. Brearley,

Chief Clerk JL

DHC

[Printer's Note: Copy of Patent No. 2,047,974, issued to P. E. Lehr et al, for "Method and Apparatus for Measuring Well Depths," attached here, is not reproduced, as it is set out in full as Plaintiffs' Exhibit No. 18, in this Book of Exhibits.]

421

1933

Contents:

1. Application.....papers.
2. Print Nov. 6, 1933.
3. Rejection Mar 8 1934.
4. Amdt. A Aug. 20, 1934.
5. Rejection Dec 14 1934.
6. Amdt B June 12 1935
7. Rejection Aug 20 1935.
8. Letter to Dfs. Sept. 23, 1935.
9. Amdt. C Sept. 23, 1935
10. Power to Inspect Jan. 27, 1936.

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